REPORT

OF THE

ENTOMOLOGICAL DEPARTMENT

OF THE

New Jersey Agricultural College Experiment Station,

New Brunswick, N. J.,

BY

JOHN B. SMITH, Sc.D.,

For the Year 1906.

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Report of the Entomological Department of the New Jersey Agricultural College Experiment Station

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GENERAL REVIEW.

The season of 1906 was characterized in its entirety by an excess of wet weather, which, while it favored the development of a few species, was on the whole adverse to insect life, and favored the development and spread of epidemic disease, such as that which was noted amongst grasshoppers. There was a steady increase in some species and, on the other hand, a distinct decrease in others that were troublesome in preceding seasons. It was in the main a favorable one for the farmer and fruit grower from the entomological standpoint, although severe individual losses were recorded.

Scale Insects.

Scale insects have been troublesome throughout the State, as usual, and on as great a variety of plants, and attention to them has occupied a considerable portion of the time of the office force.

The *San José* or pernicious scale still leads all others in importance, and has required more attention than all the remaining species taken together. The correspondence concerning it was heavy, and more than two-thirds of the time of the assistant to the State Entomologist has been devoted to inspection work in orchards and nurseries alone. Little remains to be learnt of the life history and habits of the insect, but we are far from understanding all the factors connected with its successful treatment. There has been a puzzling disagreement in the results of spraying work, and the same material used at different times and in different places has not acted in the same manner. Broadly speaking, there is not

one of the usually recommended washes that has not achieved excellent results in some hands and in some localities, and, on the other hand, there is not one that has not failed as completely at other times in other places. Of course, in many instances the causes of individual failures were obvious or discoverable, but in some others the result or lack of effect is totally inexplicable. On a subsequent page are given the results of Mr. Dickerson's observations during his tours through the orchards of the State. On the whole it may be said that the scale is under better control than ever before.*

The *oyster-shell bark-louse* comes next in importance, and in a few instances has caused as much or even greater mischief than the pernicious scale. In an apple orchard in Burlington county this insect is actually more dreaded than the other and seems more difficult of control. It is on shade trees, however, that it is usually troublesome, and on shrubs in gardens, its range of food-plants standing second only to that of its pernicious ally. Nor is it confined to any one section of the State; reports from Warren and Sussex counties being as frequent as those from Burlington and Cumberland, although the infestation is usually on different plants. Insecticide applications are rarely made as against this insect, and that it does not spread faster and does no more injury is due to natural checks entirely.

The *Scurfy Scale* attracts attention here and there, but is rarely either very abundant or troublesome. Its occurrence during the past season on certain shade trees in Newark is exceptional, and apparently there was some difficulty in dealing with it.

The *Rose Scale* occurred in notable numbers in a few localities, but chiefly in gardens and not on the berry plants that are sometimes so badly infested.

The *Cottony Maple Scale* reached the highest point in its development in 1905, and, as predicted in the previous report, its natural enemies obtained complete control of it in those localities where it appeared first and in the greatest numbers. There is no doubt that the little lady-bird beetle, *Hyperaspis signata*, deserves the chief credit for reducing the insect to normal proportions, and

* In a very few cases the scale has disappeared from badly-infested trees where no treatment at all has been made, and this has raised hopes that it might do so more generally, but there is no real evidence that this desirable consummation is anywhere near at hand.

Mr. Dickerson's observations, noted elsewhere in the report, will bring out this feature more clearly and in greater detail.

The *Maple Pseudococcus* started in large numbers and promised to become very abundant locally. It did, in fact, attract a great deal of attention, but, owing to a variety of causes, did not become as numerous as was expected. One of the causes, perhaps, was the fact that the lady-bird beetle, *Hyperaspis signata*, finding its normal food, the *Pulvinaria*, so much reduced in number, used the *Pseudococcus* as a substitute.

It was observed last fall that the insects crawled in great numbers from the upper parts of the tree to the trunk and got into the bark crevices to pass the winter. Taking advantage of this the trunks of the infested trees were sprayed with petroleum emulsion and many specimens were destroyed. As many of the insects fell with the leaves, however, and sought shelter on the ground and around the base of the trees, this method was not so completely successful as was hoped. It should be supplemented by gathering up and burning the leaves beneath infested trees as soon as possible after they fall, and by banding the tree to be protected by a complete coating of some sticky material which the insects cannot pass on their journey up the tree. On this point the notes under the heading shade tree insects should be referred to.

The *Tulip Soft Scale* was again somewhat widespread and troublesome, but, curiously enough, the greater number of complaints this past season came from the more northern sections of the State. This is an insect against which remedial measures are rarely taken, and are in fact rather difficult to make and unsatisfactory in results. Fortunately this species also is subject to parasitic attack, which, on the whole, keeps it down to inconspicuous numbers.

The *Peach Soft Scale*, an account of which was published in the report for 1905, was further observed during the past summer. No satisfactory applications were made in any orchard, and in most of the infested orchards no applications of any kind were made. In the course of his inspection work Mr. Dickerson noted the spread of the insect into adjacent orchards, so that gradually the entire district is becoming infested. Up to the present time no spread into new districts has been noted, and as the insect does not travel readily, there is no reason why, with a little care, it should not be confined to the territory now infested.

Orchard Insects.

The *plum curculio* has been as abundant as usual and has caused trouble on pear, especially the Keiffer, numerous specimens of which were found to be infested late in the season. Little attention has been paid to this habit—if indeed it be really the plum curculio that is at fault—because the trees of this variety are nearly always overloaded and the insect seems to develop only in the fruit that has dropped to the ground. It is a matter that needs further study, and, in any case, it is bad practice for horticulturists to allow fallen fruit to remain on the ground so generally. It may cost something to keep it picked up, but it will prevent the development of a great many curculios and perhaps other species as well.

The *apple borer* seems to have been unusually plentiful during the season on both apple and quince, and for the first time its injury was noted in the Experiment Orchard. With the increased care that orchards are now receiving almost universally, the occurrence of this borer is usually noted very promptly, and the larva is either cut out, destroyed by a wire or killed by means of bisulphide of carbon injected into the boring. The latter method is perhaps as effective as any and needs for an outfit a knife to clear the opening of sap and sawdust; an oil can with a slender spout, or a dropper with a rubber bulb to force in a little of the liquid; a supply of the bisulphide and a wad of putty or grafting wax to close the opening after the liquid has been injected. The vapors from the material will follow the boring and will kill the larva wherever it may be.

The record of the *Experiment Orchard* is less complete than in previous years owing to the fact that circumstances compelled me to let my place for a year, but the effect of the spraying work done in the fall of 1905 is noted, and the results of the neglect to spray with arsenites is well brought out in the large proportion of wormy and "stung" fruit which was noted.

The *pear blister mite* was more abundant and noticeable than it has been for some years past. Specimens were sent to the office in May and June, and it was noticed in the course of general examinations made in quite a number of the orchards. As a matter of fact very little actual injury was caused, and, though some badly-infested leaves turned black and fell, very little of it was seen later in the season.

Mites in general were very abundant on quite a variety of foliage and caused a good deal of spotting of leaves on peach, cherry, oak, chestnut and quite a number of other trees. These mites are very small creatures, generally known as red spiders, and they often do serious harm or cause a yellow, sickly appearance of the infested leaves. They are most abundant on the under sides and their eggs may be found on the bark of the twigs and branches

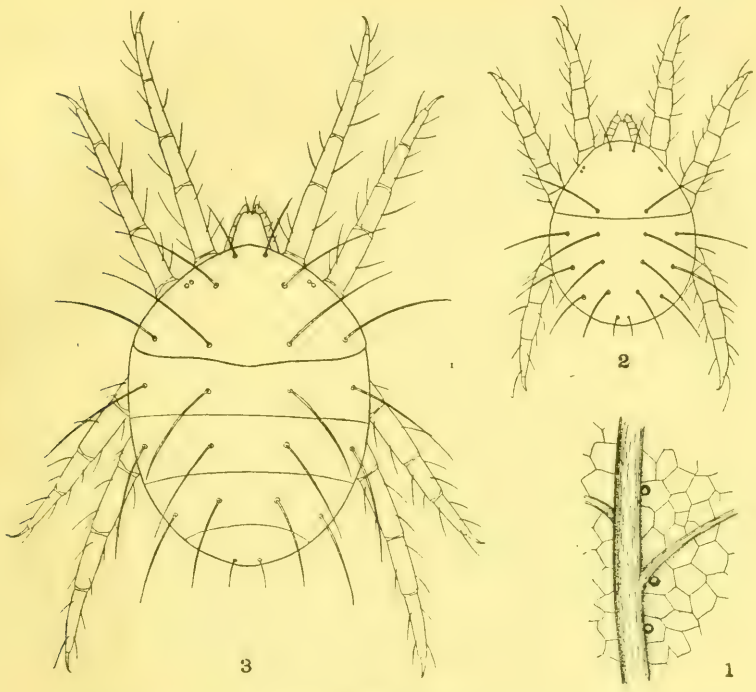

Fig. 1.

A mite: *Tetranychus mytilaspidis.* 1, the eggs on the under surface, usually laid close to a vein; 2, the six-legged young just hatched; 3, the adult mite, just visible to the unaided eye; much enlarged. Original.

during the winter. Sulphur is a very satisfactory remedy as against them, and any of the diluted sulphides may be employed as a spray. In the greenhouse flowers of sulphur may be dusted on the ground beneath infested plants.

The pear psylla.—In the report for 1905 mention was made of some Keiffer orchards in Cumberland county in which this insect had caused injury, and these orchards were revisited in March by

Mr. Dickerson. At that time the trees had been scraped and thinned by trimming, but no insecticide applications had yet been made. Numerous hibernating specimens had been observed under the loose bark and others were observed yet present in the crevices wherever examination was made. The owners were advised to burn all trimmings and scrapings and to apply petroleum in some form, driving the spray into the crevices with as much force as possible.

June 19th another examination was made, and it was found that the trees had been sprayed with a kerosene emulsion giving about 10 per cent. of actual kerosene. Examination made soon after the application showed that the insects had been killed wherever the mixture had reached them, but it was also found that by no means all of them had been reached. This was quite obvious also at the date first given, because specimens were found on both leaves and twigs, though in no great numbers. It was also learned that the pest had spread into other orchards and was obvious where none had been observed in previous years.

Fig. 2.

Pear psylla: wing adult; enlarged.

To reach this insect in its winter quarters is not altogether easy, for the adult crawls deep into every crevice or gets under every bit of available shelter, so that any ordinary spraying work will miss reaching it. Rough-barked trees should be scraped and trimmed in winter, and all the loose material should be burned at once. If it is allowed to remain for any length of time, the exposed insects on it will move away and seek other shelter and so will escape destruction, and the warmer the weather the sooner the insects will move, so that the leeway is greater in cold weather than in the warm sunshine of many March days. Kerosene emulsion or soluble oil should be applied very thoroughly, especially on the trunks and larger branches, so that all slits, cracks or crevices in the bark may be reached, and the greater the force of the spray the better the chance of a satisfactory result. Ten per cent. of actual oil will not be too strong and will give better results than a weaker solution, and if the spraying can be done on a warm, sunny day, just before the trees start, more insects will be reached than otherwise, because the oil spreads and penetrates better on a

warmed surface than on one that is dead cold. This insect is sufficiently destructive when present in large numbers to make it worth while for those fruit growers that are threatened to use effective measures to check it.

Insects on Field Crops.

The occurrence of the *army worm* at Woodbine in late August was interesting, because it was the first time since 1896 that the insect has injured field crops. It is occasionally found on grassy cranberry bogs and sometimes eats the vines when the grass has been destroyed, but on well-kept bogs, properly ditched, the injury is usually slight. As there is some reason to fear that the insect may appear again in 1907, and perhaps over a greater area, a brief record of this year's occurrence and some suggestions as to remedial measures are given on a later page.

Associated with the common species was the *fall army worm*, *Laphygma frugiperda*, which also seemed to be unusually abundant, but would not of itself have been noticeable or injurious.

The *corn-stalk borer* was not nearly so abundant as it was during the season of 1905. Nothing was added to the life history given in the last report and no experiments looking toward its destruction were made, nor was anything done by farmers, so far as I have been able to ascertain, so that the lessened numbers are due to natural causes alone. Some report of injury to corn was received, however, and near Newark the larvæ were found boring in bean and in pansy plants. There seems to be no reason to expect any immediate recurrence of the injurious increase of 1905.

Cabbage worms were abundant in many parts of the State and complaint of injury done by them was received as early as July 6th. As the season advanced the injury became more notable, and in early fall it was easy to recognize their presence by the ragged outer leaves into which holes of all sizes had been eaten. The methods of dealing with these insects are so well known and effective that it depends upon the farmer himself how much loss he suffers from them.

Grasshoppers were reported as being injurious in Morris county early in the season and occurred in great numbers near Chester, but before any serious harm had been done they became victims of disease, and in July many dead specimens were found clinging to the stalks of grasses, &c. Ordinarily, these insects do not become

at all numerous in our State until late in the summer or in early fall, and some diseased specimens are always found at that time. Nature has provided us with a very good natural check in this case which seems to become active under the same conditions that favor the development of the insects themselves.

Asparagus beetles seem to have been more abundant during the past season than for some time past. For several years very little trouble has been caused and very few complaints have been received. This year reports of injury came from several points, and they were noted as abundant in the course of field work, showing that some general conditions favored the increase of the insects.

Root maggots on onions and cabbages were very common in some localities and much damage was caused. The life history of these insects is pretty well known, but up to the present time there is no entirely satisfactory method of dealing with them. A series of experiments was planned early in the season, the co-operation of a number of growers was secured, and Mr. Dickerson was entrusted with carrying out the details of the work. While no final results have yet been attained, and some of the experiments planned could not be carried out because the materials were not all received in time, some progress was made and an account of the work done will be found on another page of this report.

Flea beetles of several varieties were locally troublesome and were reported in letters or noted in field work. Roses were injured in Bergen county by the red-legged beetle, *Crepidodera rufipes*, but the chief offender was the little black potato or tomato flea, *Epitrix cucumeris*. This has a wide range of food plants and is always more or less abundant. This season it got into young tomato plants and caused more or less damage. Finely ground tobacco was used with satisfactory results and can usually be relied upon to check the trouble. Since it has become the practice in some localities to spray the young plants with Bordeaux mixture there is very little complaint of flea beetle injury, this mixture also serving as an almost perfect protection.

Wire-worms have been locally troublesome and on a very great variety of plants. Potatoes always suffer to some extent and this year was no exception, but an attack on peach pits is added to the usual occurrences of the year. A nurseryman reports that they got into the planted pits in the nursery rows and destroyed a notable percentage of the young trees. Nothing new has developed in

the way of remedies and fall plowing of infested ground is still the most effective measure.

White grubs have been about as usual and have been complained of by strawberry growers more than any one other insect. Once the ground is infested very little can be done, but strawberries should never be set on old sod land recently turned; they should not be too liberally treated with stable manure, and they should not be allowed to become overgrown with weeds so as to attract the beetles that lay the eggs. In general, complaints are more numerous from the northern than from the southern part of the State. There is no greater enemy to the white grub than the hog, and a drove of hogs allowed to root for a week in an infested field will do more to clean it up than any insecticide application known.

Cut-worms were not more abundant than usual, but appear to have exacted no smaller toll than in other seasons. There is nearly always a short period when complaints are more or less numerous and little is heard later in the season. Gradually the growers of plants liable to injury are learning how to avoid trouble, and it is only when some unusual conditions arise that they are found unprepared. The only unusual report during the past summer was of an invasion of cranberry bogs in Burlington county, and, in this connection, a communication from Massachusetts indicates that some varieties of cut-worms may be responsible for a part of the injury charged to the so-called girdle worm.

Shade and Other Trees.

Shade tree insects continue to be objects of attention, and Bulletin No. 181, dealing with them, has been steadily called for until the edition is almost completely exhausted. The number of communities taking an active interest in the subject has increased, and on another page is given in more detail a record of the species that have proved troublesome and of the methods adopted by the various authorities in dealing with them.

The Catalpa Hawk-Moth, Daremma catalpæ has continued its northward and eastward spread and at present covers the entire State except perhaps Bergen county. The records obtained and observations made are positive for every other county, and it is more than probable that even Bergen has some centers of infestation which have not yet been reported to the office.

Fig. 3.

Tiphia Sphinx in all stages: *a*, an egg mass; *b*, *b*, young caterpillars feeding in company; *c*, grown, and *d*, a single segment from above; *e*, *f*, *h*, varieties of the larva, and *g*, *i*, single segments from above; *j*, the pupa; *k*, the adult moth; *l*, an egg much enlarged. From Rept.

It is in the nurseries that the caterpillars cause the greatest mischief, the large broods of caterpillars, unnoticed in their early stages, completely defoliating small or even large blocks in a few days before the nurseryman recognizes their presence or realizes the danger it involves. Smaller shade trees or larger single trees when infested by a sufficient number of specimens are stripped clean in less than a week, and the specimens disappear before the owner gets ready to take active measures against them. The explanation of this sudden appearance is that the broods are large, and the caterpillars from one egg-mass, 200 to 300 in number, feed in company on a few leaves until they are nearly one-third grown, and the loss of these few leaves is not noticed; then they separate somewhat and the individual eating is small until the caterpillar is nearly half grown. At that time the insects feed most voraciously and continue until they reach their full growth, each devouring several of the large leaves in the course of a week. It is at this time, when the leaves disappear so rapidly, that their presence is usually noticed.

As to remedial measures, these are simple and effectual. In nurseries a sharp lookout will detect the colonies soon after they are out of the egg and before they have done much feeding. Picking off a few leaves and crushing them under foot will then serve to destroy the entire brood, leaving the plants free until individuals of the next brood are on the wing. On shade trees and on nursery trees, if the caterpillars have begun to spread, spraying with arsenate of lead at the rate of five pounds to one hundred gallons of water should be resorted to, and will prove effective if thoroughly done and if the larvæ are not too nearly full grown. In every case the application should be made as soon as possible after the insects are discovered.

The so-called *yellow-necked caterpillars*, the larvæ of *Datana* species, have been rather plentiful on a variety of shade and other trees, and their occurrence has given rise to one report of the occurrence of the Gypsy Moth. These insects feed in companies, closely packed, and can devour an enormous amount of foliage in a very short time. They have one peculiar feature in common: when at rest the middle legs only are used to hold on, while the head and posterior end of the body are elevated or held at an angle, free from the surface on which the insects are resting.

Grape Galls.

Bladder-like galls on grape are occasionally noted each season, and in some years they are quite generally distributed and attract a great deal of attention. During the past season the trouble seems to have been quite generally distributed and reports have come from a number of localities, but chiefly the more northern sections of the State. The trouble is due to a small midge, *Lasioptera vitis,* which lays its eggs in the tissue of the leaves, leaf stalks or even the tendrils. When the egg hatches into a minute larva the plant tissue swells and forms a small or large swollen mass which, when cut, is a sappy, cellular tissue with a central cavity for the larva. A badly-infested vine presents a curious appearance in late May or early June, and after a few days little round holes appear in the swollen masses. This indicates that the insects have reached maturity and very soon thereafter the swellings disappear leaving no trace, and without permanent harm to the vine.

Rose Chafer.

This species has continued to increase and was more widely injurious than during the summer of 1905. At Vineland grapes suffered severely, but the insects were very unevenly distributed, and in some vineyards practically none at all were observed. Other fruits suffered to some extent, but no notable damage was caused. In this place, while they were more abundant than they have been for years, they are not yet as abundant as they were in 1890. At Oceanic they were also injurious to grape and attacked other fruits as well. The flowers of the tulip tree are always very attractive to the beetles, and on a poultry farm, where such a tree was in a lot used as a chicken run, the owner shook down a mass of the beetles which were promptly snapped up by the chickens. As a result twenty of them were dead next morning, and on cutting open the crops these were found packed in a solid mass with the insects. Ordinarily chickens do not touch the beetles at all, and whenever they do the result is apt to be bad, but ducks seem to manage the insects all right.

At Matawan strawberries were attacked and both foliage and fruit were eaten. At Elm, they were general in their feeding and

word was received that they had eaten up everything, but that may have been somewhat exaggerated. At Daretown, cherries suffered more than anything else; the other fruits were also eaten to some extent.

Mr. Dickerson's reports show that at various points throughout the State roses, apples and plums were more or less injured, and there is no doubt but that there is a general increase in their number and in the injury caused.

Arsenate of lead in heavy doses was tried in two instances, and in one case at least with a measure of success. In the protection of especially valuable plants or fruits this may, perhaps, prove satisfactory, but in the protection of an orchard or vineyard the expense would probably be too great. An attempt will be made next year, if possible, to test this material further.

Plant Lice.

Plant lice were nowhere very greatly abundant, nor did any especial crop suffer seriously, yet they did attract attention on a variety of plants and trees, and, on apples, were plentiful enough in a few localities to make the curled-up tips conspicuous. Other species brought to our notice in the correspondence during the season were on cherry, willow, hickory, elm, maple, melon, potato, strawberry and rose. Of the woolly lice, those on apple, alder and elm attracted attention and were reported upon. This is really an exceedingly good record for the season and shows it to be one decidedly unfavorable to the development of this type of insect.

Beneficial Insects.

Nothing was seen or heard of the *Chilocorus similis* as an enemy of the pernicious scale, and no especial search was made just where the insects had been placed, although examinations nearby would have discovered them had there been any spread. As a check to the insect against which they were introduced they may be accounted a failure, and I am not aware that in other States their success has been greater.

The little *Pentilia misella,* on the other hand, has been present everywhere, and in some places in very great numbers. Hun-

dreds of larvæ and adults were seen on individual trees, and there is no sort of doubt that this is a very real check to increase, though not yet sufficient for control. As these insects were seen in sprayed as well as unsprayed orchards, there seems to be a chance that the species will eventually prove an effective aid in disposing of those specimens that escape the most thorough winter work.

The *Chinese Mantis* has a precarious hold, and occasional specimens are taken by collectors. It has certainly not become numerous enough to be of any use. Early in December Mr. Phil. Laurent again offered to secure egg masses for us, and by the 16th of that month three hundred had been received. Two of these masses were tied out next to the Experiment Orchard, and one nearly full-grown specimen was observed during the summer. The balance of the eggs were tied out in the Orange mountains by Messrs. Brehme and Dickerson, near South Orange.

It was determined to give these insects every chance that a large colony would offer to sustain themselves, and to find mates if even a small percentage only survived. The place selected was a secluded spot on top of the mountain, perhaps an acre or two in extent, overgrown with rank vegetation and bushes, and almost surrounded by woods. It was an ideal place for insects, and there, if anywhere, it was believed, the Mantids would be able to find a living. The egg masses were tied on the bushes and tall plants, usually about a foot or thereabouts from the surface. This low position was chosen because some of the masses in previous years had been apparently picked by birds, but the new location was even worse, because when in early spring an examination was made, it was found that field mice had eaten out the great majority of all the masses. Whether enough have escaped to form a colony cannot be positively determined as yet.

Miscellaneous.

Among the other insects that were sent in for determination and which were locally troublesome were, among the beetles, borers of various kinds in maple, in grape buds and in some shade trees, the "Buffalo moth," the fruit tree bark beetle, a bark beetle on maple and the Indian Cetonia.

Among the *Lepidoptera* were the cranberry moths, the peach

borer, the *imperialis* caterpillar, the *io* moth, the *cynthia* moth on *Ailanthus*, a small larva on the leaves of tulip trees, an undetermined caterpillar on chestnut, the *Sphinx* larvæ on tomatoes, the *inclusa* caterpillars on poplar, the wood leopard moth and the Tussock moths.

Among the *Hemiptera* or true bugs other than the plant lice were spittle insects, *Aphrophora parallela*, on pine, the various orchard and shade tree scales, and Thripids on peach and on greenhouse plants. On the latter, by the bye, cold water was applied with good results.

Among the *Hymenoptera* were ants of several species infesting lawns and injured trees, some oak galls and the Pigeon Tremex.

Among the *Diptera* or flies were the Hessian fly, the wheat stem maggot and certain fungus gnats.

Insecticides and their action continued to form one of the subjects to which attention was directed, and a considerable number of direct experiments were made under supervision of the Entomologist, and a much greater number of what may be called field trials by practical fruit growers and farmers were carefully observed as to methods of application and results. These observations are reported upon, partly under the general head of Insecticides and partly in the record of observations made on the root maggots.

Owing in part to ill-health, the Entomologist was accorded a long vacation so that the practical work of carrying out the planned experiments and the making of records of results fell largely upon Mr. E. L. Dickerson, assistant to the State Entomologist, who is credited in the body of the report with the specific worked looked after by him.

No bulletins were issued during the year from the date of the last report, but, as already stated, material is in hand for an essay on Root Maggots. Miss A. E. Meske is still office assistant and stenographer, and, with Mr. Dickerson on the staff of the State Entomologist, whose report is made to the State Board of Agriculture.

The equipment of the department has been fully kept up, and minor additions are constantly made as they are brought to our attention. The collections have increased in extent and variety, and further boxes have been prepared for the State Museum at

Trenton, as will appear in the report of the Curator, Mr. Silas R. Morse.

The session of the Horticultural Inspectors held at the city of Washington during the middle of November was attended as representative of the New Jersey Stations, and a trip was made into the newly-developed apple-growing districts near Martinsburg, W. Va., where also the works of the American Horticultural Distributing Company were visited and their method of making insecticides—Target Brand Emulsion and Arsenate of Lead—was observed. Some of the information gained will be found on another page of this report.

The usual work of attending institute and other farmers' meetings throughout the State has been continued, and many lectures have been given, not only on the general topics dealing with insects injurious to crops, but with the mosquito pest in all its variations. So, also, continuing good relations have been maintained with entomologists and entomological societies, as heretofore.

Mr. John A. Grossbeck, assistant in the mosquito investigation, has materially assisted at times in the general work of the Station, and to his artistic skill the illustrations in this report will testify.

The correspondence of the office during the past year was somewhat less than usual, owing to my long absence from office work, covering 1654 pages of letter-books and representing about 2500 individual communications.

RECORD OF THE EXPERIMENT ORCHARD.

All the trees were sprayed with "Scalecide," 1 to 20, on November 16th, 1905, by Mr. Dickerson, who made the following note: "This afternoon sprayed all the trees in the Experiment Orchard with Scalecide at a strength of 1-12, and sprayed thoroughly except a few along the fence on side next to the street. These were pretty thoroughly sprayed, but difficult to spray from both sides."

A few days later another application was made to the trees not properly treated, and there was a general touching up of trees that seemed to need it. Apparently no memorandum of this application was made.

For personal reasons, my house and grounds were let during

1906, and no further applications of any kind were made between the time above mentioned and November 1st, 1906. I did not personally see any of the trees during that same period, but Mr. Dickerson examined them at intervals and recorded as follows:

July 2d.—Looked over the trees and found them in the following condition:

Tree 1—*Mariana Plum.* General appearance good, and making good growth; very few plums on tree; a few of the leaves eaten by the rose chafer; very few scale larvæ or recent sets observed.

Tree 2—*Yellow Transparent Apple.* General appearance good; four good apples observed; leaves in many cases show effects of leaf hopper; *Pentilia* seen on one of the branches, as well as woolly lice on a few of the knots; very few scale larvæ or recent sets observed.

Tree 3—*Black Tartarian Cherry.* In good condition, without any signs of larvæ or recent sets of scale.

Tree 7—*Champion Peach.* Some twigs and small branches throughout the tree dead; lower branches well loaded with fruit, some of which were "stung;" scale apparently cleaned out.

Tree 8—*Grimes' Golden Pippin.* General appearance good; few apples, mostly in good condition, but some showing work of codling moth and curculio; apparently little or no live scale; no crawling larvæ or sets observed.

Tree 15—*Japan Golden Russet Pear.* General appearance of tree good; plenty of fruit on tree and scale apparently cleaned out.

Tree 16—*Japan Golden Russet Pear.* In same condition as No. 15.

Tree 17—*Trellised Peach.* Pretty well set with fruit, but about every one "stung" at least once and many more than once; live scales apparently very scarce.

Tree 18—*Vermont Beauty Pear.* A little live scale on this tree and most apparent on pears, some of which have at least a dozen sets. There is quite a setting of fruit, some of which also shows signs of curculio.

Tree 19—*Vermont Beauty Pear.* This tree is in just about the same condition as No. 18, but on a couple of small limbs toward the house there is quite a sprinkling of larvæ and recent sets; the branches must have been missed in spraying. There is rather a

light set of fruit and there were some webs of the fall web-worm which were removed.

Tree 20—*Meech Quince.* General appearance good; very little live scale observed; web-worms on one limb, next to No. 19.

Tree 23—*Greensboro Peach.* General appearance good; well set with fruit; no live scale observed.

Tree 24—*Greensboro Peach.* Similar to No. 23; but a portion of the fruit dried up when small; larvæ and sets very scarce.

Tree 25—*Apricot.* General appearance good; scale pretty thoroughly cleaned out.

Tree 26—*Nectarine.* Some dead twigs and shoots which should be cut out, but making good new growth; leaves not particularly smooth; scale apparently cleaned out.

Tree 29—*Gravenstein Apple.* Very little fruit and part at least is "stung" and wormy; some drops on ground; scale apparently pretty well killed.

Tree 30—*Grimes' Golden Pippin.* General appearance good; small crop of fruit, nearly every one stung and many wormy; apparently free from live scale.

Tree 31—*German Prune.* General condition good; well set with fruit, but hardly one which has not been stung. Plant lice have been pretty thick at tips of some branches, but now are pretty well dried up and dead. Scale has been apparently killed.

Tree 32—*Mountain Rose Peach.* General appearance good, with a light crop of fruit; apparently little or no live scale.

Tree 33—*Dwarf Duchesse Pear.* General condition good and making good growth; very little fruit; no scale larvæ or sets observed and live scales apparently cleaned out.

Tree 35—*Japanese Walnut.* General appearance good; a few scale larvæ and sets observed.

Tree 38—*Baldwin Apple.* Has a good, rank appearance; very little fruit; scales apparently dead.

Tree 42—*Elberta Peach.* In good condition with small crop of fruit; no signs of crawling larvæ or live scales.

Tree 43—*Early Richmond Cherry.* Tree in good condition with no signs of scale upon it.

Tree 44—*Elberta Peach.* Foliage rather thin, but looking fairly well and well set with fruit. Some dropped fruit and a little dry rot; scale apparently killed.

Tree 46—*Japanese Chestnut.* In good condition, with several blossom clusters; apparently no scale.

Tree 47—*Greensboro Peach.* In good condition, free from scale, with a heavy crop of fruit.

Tree 48—*Black Tartarian Cherry.* Tree in good condition.

The notable features of this record are the large measure of freedom from scale and the large amount of "stung" and wormy fruit. Only on those trees—Vermont Beauty Pear—that were badly infested last season was any notable remnant present, and this was due to the fall application of 1 to 20 Scalecide. The absence of the usual arsenical sprayings is very well shown by the infested fruit and by the presence of the web-worms.

July 23d, word was received that some of the peach trees were overloaded and breaking, so Mr. Dickerson and Mr. Grossbeck went up, and did as follows:

Tree 7—*Champion Peach.* Picked off a large grape basket of green peaches and left enough to tax the tree on the bearing branches.

Tree 23—*Greensboro Peach.* Branches bent over with weight of fruit; picked off more than two-thirds of a basket of ripe fruit and left nearly as much remaining. Fruit of good quality.

Tree 24—*Greensboro Peach.* Branches bent down with weight of fruit; topmost branches broken off. Took off three-fourths of a basket of peaches, mostly ripe and of good quality, and left on half a basket more.

Tree 44—*Elberta Peach.* Dead or dying; all leaves off. Report of tenant was that it got into this condition about the middle of the month.

This is one of the trees that became so badly infested in 1903 that it was dehorned or cut back to stubby branches from the trunk. It did well in 1904 and made a heavy crop in 1905, which rotted before it ripened. It went into the winter in apparent good condition, but was already off color when Mr. Dickerson saw it in the early part of the month.

Tree 47—*Greensboro Peach.* Loaded with fruit and two small top branches broken; picked off a basket of ripe peaches, of good quality, and left half as many more on the tree.

Further examinations were made August 8th, and again October 20th, no applications of any kind having been made in the

intervening period. The conditions found on the two dates are recorded as follows:

Tree 1—*Mariana Plum.* August 8th, condition good, growing well, scales very scarce. October 20th, very free from scale and in good condition.

Tree 2—*Yellow Transparent Apple.* August 8th, very free from scale and growing well. Quite a few leaf hoppers—nymphs and adults—and almost every leaf shows the effect of their work by the discolored upper surface. October 20th, a very little setting of scale; the leaves, which to a large extent remain, show leaf-hopper injury to a marked extent.

Tree 3—*Black Tartarian Cherry.* August 8th, condition very satisfactory. October 20th, in fine, thrifty condition.

Tree 7—*Champion Peach.* August 8th, looking well and very free from scale; the thinned fruit developing nicely. October 20th, apparently very clean; on a few of the leaves near the trunk were signs of red spider and some specimens were yet present.

Tree 8—*Grimes' Golden Pippin.* August 8th, making a good growth, and very free from scale. Leaves badly discolored by leaf hoppers. October 20th, leaf-hopper injury very apparent on most of the leaves; very slight setting of scales on such branches as I was able to examine.

Tree 15—*Japan Golden Russet Pear.* August 8th, was in good condition, making good growth, very free from scale and with plenty of fruit. October 20th, plenty of ripening fruit; enough to break a couple of limbs; very little, if any, scale.

Tree 16—*Japan Golden Russet Pear*—Same record as for the preceding.

Tree 17—*Trellised Peach.* August 8th, not particularly thrifty; all of the fruit rotted; plenty of old scale covering, but very few living insects. October 20th, scale infestation very slight; red spider present on some of the leaves.

Tree 18—*Vermont Beauty Pear.* August 8th, doing fairly well, with a light set of fruit; while many of the pears are clean, there is a little setting of scale on some around the blossom end and quite a sprinkling of fresh sets on the tree. October 20th, leaves were about all off and there was a scattering infestation, including some fresh sets; some of the scurfy covering of last year's infestation killed by the spray was still present.

Tree 19—*Vermont Beauty Pear.* August 8th, conditions very similar to No. 18, but on a couple of branches quite a little scale infestation; from one branch two small nests of fall web-worms were removed and the tip of one branch has blighted back about eighteen inches. October 20th, similar, still, to No. 18, with more foliage remaining and more scale on some branches than were present at last inspection.

Tree 20—*Meech Quince.* August 8th, doing well and very free from scale; a few tips blighting; small set of fruit. October 20th, was no worse than before.

Tree 23—*Greensboro Peach.* August 8th, fruit all off; looks well; making a good growth, and keeps very clean. October 20th, was still good, and scale infestation very slight.

Tree 24—*Greensboro Peach.* Conditions on both dates were very similar to those on No. 23.

Tree 25—*Apricot.* August 8th, was making a heavy growth of top; was looking well, and was very free from scale. October 20th, matters had not become worse.

Tree 26—*Nectarine.* August 8th, a few small branches dead, apparently killed by heavy scale infestation of last year, else now in good shape, making fine growth, with very little scale and one fruit. October 20th, matters were no worse, and the tree was doing well.

Tree 29—*Gravenstein Apple.* August 8th, no fruit left; very free from scale; most of the leaves more or less injured by leaf hoppers. October 20th, was apparently doing well, and with a slight setting of scale; work of the apple borer was in evidence near the ground; the several borings were examined, treated with carbon disulphide and plugged with cotton saturated with it. In one boring a nearly full-grown larva was destroyed.

Tree 30—*Grimes' Golden Pippin.* August 8th, in good shape, but foliage spotted by leaf hoppers; no scale on fruit, which is nearly all wormy, and some injured by curculio. October 20th, conditions were no worse, and the tree was practically free from scale.

Tree 31—*German Prune.* August 8th, was in good condition; looking well, and practically free from scale; fruit clean; some has dropped; is now ripening; some of it stung. October 20th, continued in good condition, but has a scattering set of new scales.

Tree 32—*Mountain Rose Peach.* August 8th, was looking and growing well; very free from scale; fruit coloring up and maturing well. October 20th, was still doing well, and continues very free from scale.

Tree 33—*Dwarf Duchesse Pear.* August 8th, was doing fairly well; very free from scale; very little fruit; slug work present on a few of the leaves. October 20th, was just beginning to show a slight infestation of new scales.

Tree 35—*Japan Walnut.* August 8th, in fine condition, and apparently very free from scale, but now so large that it cannot well be examined. October 20th, was certainly no worse.

Tree 38—*Baldwin Apple.* August 8th, was doing well, and very free from scale; leaves pretty well spotted by leaf hopper. October 20th, was no worse than at last inspection.

Tree 42—*Elberta Peach.* Very free from scale, and looking fairly well, but foliage too light in color; small crop of fruit. October 20th, was still very free from scale, but the leaves showed injury from red spider.

Tree 43—*Early Richmond Cherry.* August 8th, the tree was doing well, and was free from scale, and on October 20th conditions had not changed.

Tree 46—*Japanese Chestnut.* August 8th, there was a small crop of nuts and no scales, but the foliage seemed a little dry, and was too light in color. October 20th, the injury to foliage was seen to be due to red spider, which had been very bad on this tree, sucking the life out of the leaves and causing them to dry and fall.

Tree 47—*Greensboro Peach.* August 8th, fruit all gone; tree looking well and free from scale. October 20th, conditions were no worse.

Tree 48—*Black Tartarian Cherry.* Continued to look well, and was free from scale throughout the entire season.

Mr. Dickerson's comment on October 20th is that "the orchard has remained in good condition, on the whole, all summer, and, with the exception of the Vermont Beauty Pears, very free from scale."

The lack of attention and spraying with the arsenites favored the development of slugs, web-worms, codling moths and curculios, while the red spider could have been kept in check with an oil emulsion or one of the sulphur sprays.

ENTOMOLOGY IN THE CROP BULLETIN.

The Crop Bulletin issued by the State Weather Service was discontinued at the end of the season of 1905, and its place is taken by the Crop and Agricultural Bulletin of the New Jersey State Board of Agriculture. This is issued monthly, instead of weekly, and the reports, so far as the insects are concerned, do not present so complete a picture of the season's happenings.

In May, the *San José Scale* was working fatally in all unsprayed orchards near Park Ridge, Bergen county; it was also rampant near Baptisttown, in Hunterdon county; near New Market, in Middlesex county, the fruit did not look well on account of the scale, and not much spraying had yet been done in that locality. At Freehold, Monmouth county, the prospect for fruit was good where the trees were well cared for and sprayed. Scalecide was used for the scale in place of the salt, sulphur and lime. Near Moorestown, Burlington county, apples, where not too much injured by scale, looked promising.

Flea beetles were eating tomato plants near Hopewell, Mercer county. At Imlaystown, Monmouth county, apple trees were full of fruit, but the *caterpillars* were almost stripping the trees of their leaves. *Cut-worms* were exceedingly abundant and destructive at Mount Laurel, in Burlington county. Potatoes were full of *bugs* at the same place, and much the same report came from Green Creek, Cape May county. *Lousy corn* occurred at Shiloh, in Cumberland county, and the *Curculio* was abundant at Cologne, Atlantic county.

In June, at Locktown, in Hunterdon county, hopes were entertained that the *scale* was being controlled; but at Athenia, Passaic county, the coming fruit crop was estimated low because of scale injury. *Potato beetles* continued to be numerous at Locktown; they had been very bad at Dutch Neck, in Mercer county, and were exceptionally bad near Moorestown, in Burlington county. *Rose bugs* damaged, and in some instances completely destroyed, sweet cherries near Park Ridge, Bergen county; they cut into the raspberry crop at Hammonton, Atlantic county, and were very destructive to cherries near Shiloh, in Hunterdon county. *Peach* and *squash borers* were reported as apparently exterminated by weather conditions at Dover, Morris county. *Worms*

in cherries lessened the crop at Cranford, Union county, where the non-occurrence of the Periodical Cicada is also made a matter of positive note. *Cut-worms* were charged with a loss of twenty-five per cent. of the cabbage crop at Athenia, Bergen county; they compelled the replanting of tomatoes and troubled corn near Hopewell, in Mercer county; kept back corn near Moorestown, and delayed the starting of gardens at Mount Laurel, both in Burlington county; finally, small caterpillars were charged with causing a bad dropping of the leaves of Norway maples at Hopewell, Mercer county.

In July, *Scale* ravages were not showing as bad as in the two last preceding years, which may be due to the fact, which was also noted, that some spraying had been done, near Morristown, in Morris county. *Wormy apples* were reported from Matawan, Monmouth county, which may, in part at least, be explained by the further report, "no spraying of consequence done here."

In September, *San José Scale* threatened the total destruction of the apple industry at Baptisttown, Hunterdon county; many apple trees were dead through it at Preakness, Passaic county, and blight and scale together caused light crops of apples and pears at Hopewell, Mercer county. It is comforting to learn, from Livingston, in Essex county, that the fruit was clean and showed no signs of scale.

In October, Park Ridge, Bergen county, complains of two things—"increasing taxation, with but little to show for it, and the San José scale, with too much to show for it." That all is not yet lost is shown by the added note that "very many will spray in the fall, as well as in the spring." At Cohansey, Salem county, late-threshed wheat was badly cut by the *grain moth*, and much of it was not fit for flour.

THE ARMY WORM.

Leucania unipuncta Haw.

This insect is rarely troublesome in New Jersey, although the adult moth is one of the commonest of its tribe found by the collector. Its normal food plants, the grasses, are, however, so plentiful everywhere that a great number of individuals develop absolutely unnoticed every season. They are kept in check as a rule by parasites, to which they are greatly subject, and by diseases

which attack the caterpillars and prevent them from reaching their full development. Occasionally these checks are wholly or partially absent, either locally or over a considerable territory, and then the species increases rapidly and becomes more or less injurious.

Usually it is when a dry autumn is followed by a moderately severe winter and a dry spring that danger may be expected, but there seems to be no absolute rule in the matter.

Fig. 4.
The Army Worm. After Riley.

In 1889 the species was troublesome in a few localities, and in 1896 it appeared in several sections of the State, the reports for these years giving details of the injuries done. Since that time, and until the past summer, no complaints were received, but near the end of August the caterpillars were found at Woodbine, Cape May county, and Mr. Dickerson went down September 1st to investigate. It was found that the crops on about ten acres had been pretty thoroughly destroyed, and damage to the extent of several hundred dollars had been done. According to Professor Pincus, of the Agricultural School, the caterpillars had been observed in small numbers in the German millet about ten days previously, but on account of rainy weather they were not again observed until a week later, when it was found that they had done considerable damage.

After so eating the German millet that there were only long stubbles left, they migrated on the one side into the field of Japanese millet, destroying that, and then into a field of corn next to that. On the opposite side they entered a field of corn and had already injured a few rows. On the third side of the German millet they crossed the road and established themselves in a field of cow peas and kaffir corn. They ate the corn and left the peas, apparently avoiding leguminous crops. The fourth side of the millet field first infested adjoined a piece of scrub land, which the larvæ did not enter. There was a small plot of German millet a short distance from the general infested area, and that also was eaten up. The Japanese millet was more mature than the German variety, and on this the head as well as the stalk was left.

At the time of Mr. Dickerson's visit most of the caterpillars

were nearly full grown, but quite a number of small specimens remained, capable of considerable mischief. A number of the caterpillars were brought back to the laboratory, and more than half of these developed normally into moths a short time afterward.

When the office was notified of the occurrence of the insects, ditching and spraying were recommended, and this recommendation was followed. Mr. Dickerson found that ditches nearly a foot wide and one and one-half feet deep had been dug around the

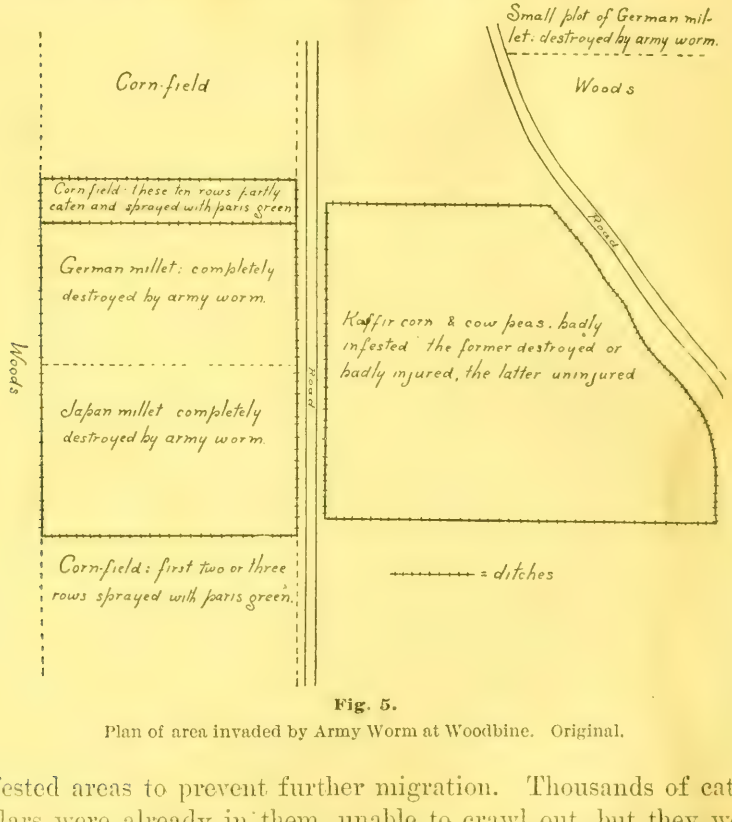

Fig. 5.

Plan of area invaded by Army Worm at Woodbine. Original.

infested areas to prevent further migration. Thousands of caterpillars were already in them, unable to crawl out, but they were sprinkled, nevertheless, with kerosene to prevent the development of those that were already mature and ready to pupate. The rows of corn to which the larvæ had penetrated before the ditches were dug were thoroughly sprayed with kerosene.

Quite unusually the caterpillars were free from parasitic or disease attack. While in previous invasions which I had observed the

Fig. 6.

Ditching across the line of the Army Worm march. Original photograph.

Fig. 7.

A hill of corn, showing Army Worm injury. Original photograph.

vast majority of all the larvæ were parasitized, this time parasites were almost absent, and all the larvæ brought in pupated, although not all reached the adult stage. The only disease present was where the larvæ were crowded in great numbers on corn, when veritable decaying masses of them were lodged at the bases of the leaves and close to the stalk.

This absence of parasitism and disease leads to the fear that, if the spring of 1907 is favorable, the insects may appear in yet greater numbers and over a larger extent of territory, hence a brief account of the life history and of the methods adopted to prevent injury are here given:

Life History.

The adult is a so-called "miller" or owlet moth, such as is often attracted to light on hot, sultry nights; of a dark reddish clay color, powdered with black atoms, and a little white spot near the middle of the fore wings, from which the name is derived. It is in this moth stage that the insect usually lives through the winter, or hibernates, although hibernation in the pupal stage is not uncommon, and it may also occur in the larval stage.

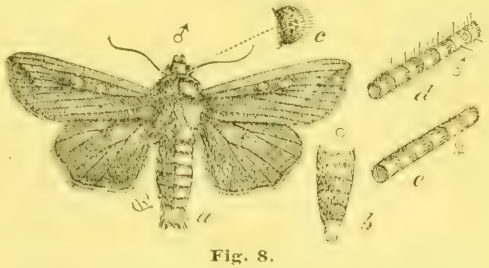

Fig. 8.

Leucania unipuncta: parent moth of Army Worm, with some details of structure. After Riley.

This moth, whether it hibernates or whether it emerges from the pupa in early spring, lays its eggs on grass or grain, favoring under ordinary circumstances the rankest and densest growth, because it finds there the best shelter for the five to eight hundred eggs which constitute the supply of one female. The eggs are laid close together, in series of twenty or more, and are covered with a whitish, adhesive fluid, which fastens them to each other and holds them in position on the grass blade. They hatch in about a week from the time they were first laid and produce a dull reddish or brown caterpillar marked with yellow and black longitudinal lines. Growth continues until these caterpillars become nearly two inches in length, and then they make their way to the ground and change

to mahogany brown pupæ about two inches below the surface—less in summer than in late fall, when they usually go nearer the frost line. In from one to two weeks afterward the adults make their appearance and soon thereafter another life cycle begins. Under ordinary circumstances, six weeks from the egg to the resulting adult may be considered about normal, but in midsummer the period may be shortened to a month, and in cool weather may be lengthened to nearly double that time. Three broods during the season are usual, although there may be a partial fourth, which matures so late that many of the pupæ hibernate.

It is rare for the spring brood to be sufficiently numerous to become noticeable, and even the second or early summer brood rarely attracts much attention, but in late summer, when the third brood in a favorable season becomes half grown, they are present in such enormous numbers that in a few days an entire field is cut down and a march is begun. These "armies" on the march follow no order or system; it is merely a search for food, and each individual halts as soon as it has found something to feed upon, resuming its place in the line as soon as hunger can no longer be satisfied. While they occur in moderate numbers the larvæ usually feed at night and hide at the base of the plants during the day, but when their numbers become so great that the food-supply is scant they eat at all times when opportunity offers.

Remedial Measures.

It has been stated that the adult usually lays its eggs in the densest and rankest part of a grain or grassfield, and it is from such spots that the insects usually spread or from which an "army" starts. When such an infested patch is discovered, it should be isolated at once by plowing a deep furrow completely around it, steep side outward. If the furrow is imperfect, mend with a spade so that the caterpillars may find it impossible to crawl out. A ditch may be dug instead, if more feasible. At intervals of ten feet or thereabouts drive post holes or dig a deeper hole. The caterpillars having entered the furrow or ditch, and finding it difficult to scale the further side, naturally crawl along the bottom until a post hole is reached. They tumble into that and are then utterly unable to escape. To prevent any from maturing, kerosene may be

poured into the holes once or twice a day, until no more caterpillars are in the ditch or furrow.

Having isolated the infested area, if the plants are corn, they may be heavily sprayed with arsenate of lead, one pound to ten gallons of water, to kill the caterpillars feeding on them. Arsenate of lead is recommended because it may be used very strong without causing injury to the plants, but Paris green, one pound in one hundred gallons of water, will answer as well, except that it will burn the leaves to a greater or less extent. Spraying wheat, millet or other narrow-leafed grasses with arsenites is not recommended, because of the difficulty in making the material stick, but kerosene may be used to good advantage if the crop is so far gone as to be valueless.

If the caterpillars are less than two-thirds grown, advantage may be taken of their fondness for bran, and dry bran mixed with white arsenic, at the rate of one pound of arsenic to fifty pounds of bran, may be scattered liberally over the ground or among the plants. Paris green, at the rate of one pound to twenty-five pounds of bran, will do as well. Most of the caterpillars tend to get down from the plants during the middle of the day, and will find the bran before they climb for another meal. Where a brood is discovered early, this poisoned bran treatment may be all that is necessary. Where the insects are not discovered until they have begun to spread, the first thought should be to limit them by the furrow as already described.

Natural Enemies.

It has been stated that the caterpillars this year were unusually free from parasites. This statement is based partly upon the laboratory results and partly upon the fact that no eggs of *Nemoraea leucaniæ* Kirkp., were noted on them. This *Nemoraea leucaniæ* is a good-sized bluish fly, something like the ordinary blue-bottle in appearance, and it lays its white eggs on the back of the caterpillar just behind the jaws or legs. These eggs are easily visible and their practical absence this year indicates a very heavy brood of late adults and may mean danger next year.

In the ditches a few examples of caterpillar hunters—large predatory beetles of the genus *Calosoma*—were observed, but not in sufficient numbers to have any perceptible effect in reducing the number of "worms."

THE GYPSY MOTH.

Porthetria dispar Linn.

In the report for 1905 there is an account of this insect, with a history of its spread in the United States, the injuries caused by it and the menace of its introduction into New Jersey. It was not known at the time that as a matter of fact the insect had been already introduced into the State by an experimenter, who had, as he believed, perfected a method for its destruction.

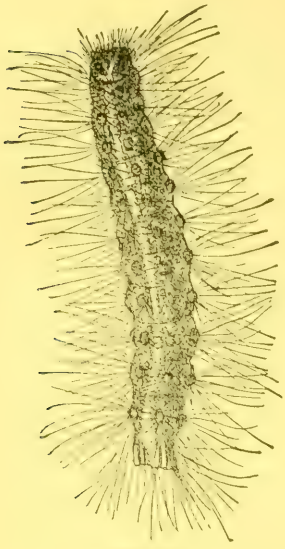

Fig. 9.

Caterpillar of Gypsy Moth; full grown. From Div. Ent. U. S. Dept. Agl.

The matter came to the attention of Mr. A. H. Kirkland, superintendent for suppressing the gypsy and brown-tail moths in Massachusetts, and he at once communicated with the office. Mr. Dickerson, who was in charge during the absence of the entomologist, at once visited the point where the introduction was made, found that there was no immediate danger and left the matter for further investigation later.

On my return, in early April, I took the matter up at once; found that during the winter of 1903-1904 a resident of Madison, developing an insecticide, was induced by a friend to try it on the gypsy moth, egg-masses of which were sent in by mail for that purpose by the obliging friend. The egg-masses were received very early in spring, were hatched in a greenhouse before any vegetation had started outdoors, and the caterpillars were fed on dwarf maples until outdoor foliage was available. When the larvæ were half grown the poison was tested, and a large proportion were destroyed. Finally, all remaining larvæ were destroyed and the greenhouse was fumigated with sulphur before it was opened for the summer. I was assured that no eggs were placed outdoors and no larvæ were allowed to escape. Also, that only one lot was received and all were used in the one place, near Stanley, in Morris county.

Under my instructions, Mr. Dickerson went to Stanley, July 3d, armed with a powerful Zeiss stereo-field glass, and reports as follows: "I drove directly to the greenhouse, looked carefully around it in all directions, in the lots and woods which surround it. I also followed out the various roads for a considerable distance, but nowhere could I see any signs of caterpillar injury—in fact, the vegetation and trees seemed unusually free from infestation."

On August 6th Mr. Dickerson again visited the locality, and was then accompanied by Mr. Grossbeck. His report continues: "This time, after looking carefully around the greenhouse, we drove along the various roads passing by or near it, and went much further than on the first visit. Mr. Grossbeck kept a close lookout

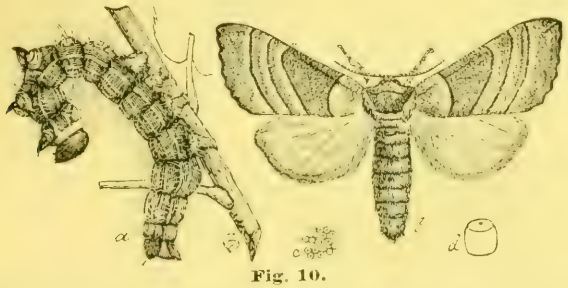

Fig. 10.

Yellow-necked Caterpillar (*a*) and its parent moth (*b*); eggs (*c*), natural size and (*d*) enlarged. After Riley.

on the trees and bushes on one side of the road and in this way we covered the ground very completely. The results were similar to those of the first visit; the trees were exceptionally free from caterpillar attack and no signs of the gypsy moth were observed." It should be said that for a space of several hundred feet from the greenhouse the ground was covered, on foot, in every direction, and the driving was a slow walk, with frequent stops to investigate suspicious appearances.

July 27th, Mr. Kirkland again communicated with the office, enclosing a clipping from the Springfield, Mass., "Republican," which recorded the appearance of the gypsy moth in Trenton. A similar note appeared in the Boston "Globe" of July 22d, and this was furnished by the Associated Press, through the New York "World."

The matter was investigated by Mr. Dickerson and traced to the Trenton "Times," from whom he obtained the name and address of the person who observed the insects. The place was visited and carefully inspected early in September. No trace of the gypsy moth in any stage was observed, and from the description that was given of the caterpillars, it appears certain that a species of *Datana* was in fault, the caterpillars resembling those of the gypsy moth to a considerable extent. At all events, it seems reasonably sure that up to the present time the gypsy has not actually appeared within our limits.

Several inquiries have come from different parts of the State asking information concerning the insect, and specimens as unlike as the caterpillar of the *imperialis* moth have been sent in to determine whether or not it was the gypsy or brown-tail.

Reports of the occurrence of the insect in New York City were investigated by the local authorities and proved unfounded, but at Stonington, in Connecticut, a colony has been found and observed by the entomologist in that State and by agents of the United States Department of Agriculture.

ROOT MAGGOTS.

Maggots on the roots of onions and on the various cruciferous plants are more or less troublesome each year, sometimes locally, sometimes throughout the entire State, and there are no insects that are more difficult to deal with. I have kept track carefully of the experimental work done throughout the country and of the various applications made in our own State in the hope of gaining some information that would enable us to deal with them more certainly and effectively. It is remarkable what a large number of remedial measures have been proposed, how successful they seem to have been in some cases and what failures they have been with others. It is also puzzling to find that conditions of soil and locality seem to affect the action of the materials in a varying way, and how apparently eccentric the insects themselves are in their appearance. A locality may be badly infested one year and free the next, and the reverse is equally true. There may be a series of bad years or a series of exempt periods; there may be only a single destructive brood a season, or the maggots may be troublesome

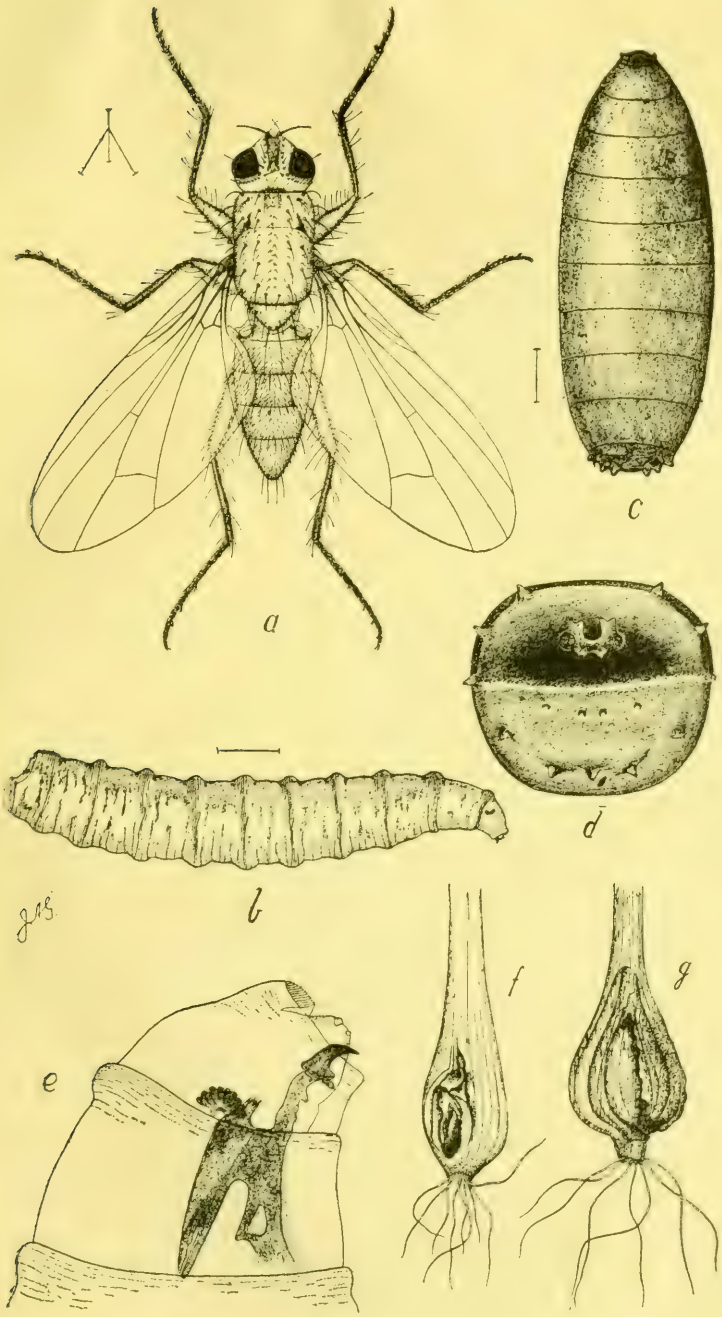

Fig. 11.

The Onion Fly, *Pegomyia cepetorum*: *a*, adult; *b*, maggot; *c*, pupa; *d*, anal end of maggot with breathing holes; *e*, head with mouth structures—all very much enlarged; *f* and *g* show injury on young onions. Original.

throughout the growing period. These irregularities of appearance have interfered somewhat with our judgment concerning the value of preventive application, because in some cases at least it was an open question whether exemption from attack was due to the application or to some natural cause that would have produced the same effect had no application whatever been made.

Despite these difficulties it was decided to attempt a series of field experiments on cabbage and onion maggots during the season of 1906, and to secure the co-operation of a few practical growers, materials to be furnished by the office, growers to make the applications, results to be judged by both parties.

Briefly stated the life cycle of the common root maggots is as follows: The adult flies live throughout the winter in such shelter as

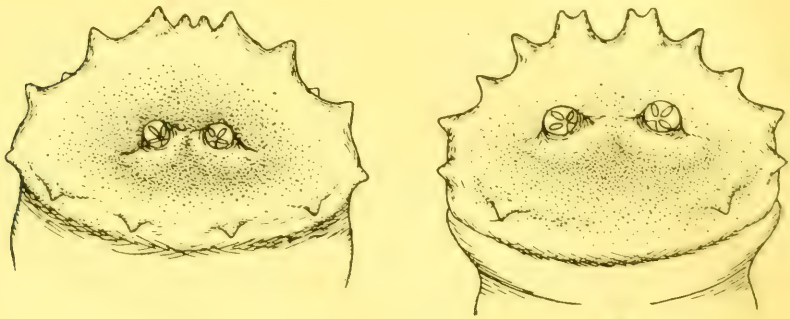

Fig. 12.

End segments of the Onion Maggot (1) and of the Cabbage Maggot (2); much enlarged. Original.

they can find about the farm. They appear in spring about the time their food plants are well started, lay their eggs on the plant as near to the surface of the soil as possible, and when these hatch, within a day or two, the young maggots begin to dig their way into the root, stem or bulb, as the case may be. Injury does not usually become noticeable until the maggots are so well advanced in growth, or so protected by being imbedded in plant tissue, that remedial measures are apt to be too late to kill the insects or to save the plants. When full grown the maggots usually move a little distance from the plant, contract and form pupal cases, and lie quietly a few days before the final change to the adult fly. There may be several destructive broods in the course of the season, or

there may be only a spring or spring and fall brood, but in every case the larval life is short, and the life of the adult extends through an unknown period.

The Materials to be Tested.

Some of the applications to be made were of well-known materials, with which contradictory results had been obtained, and some were tried simply to see how results in different hands and in diverse localities would compare.

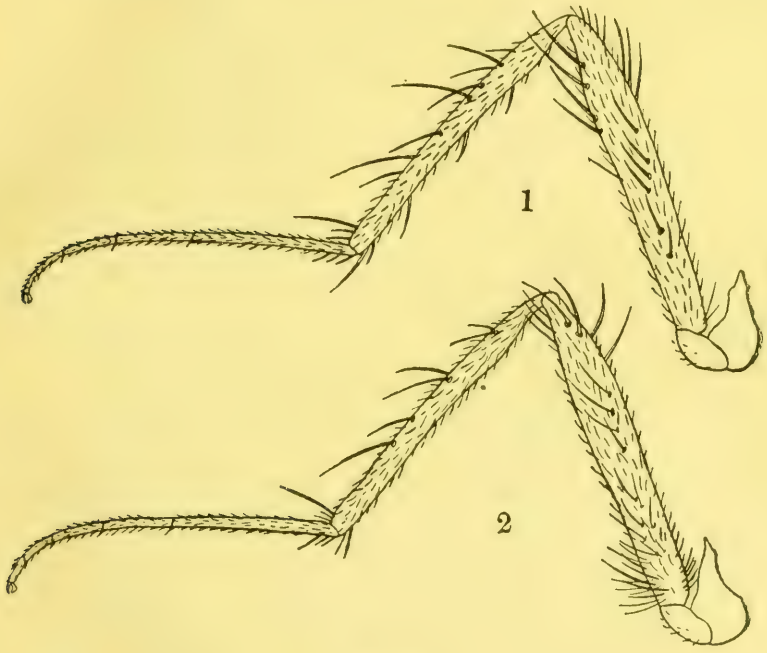

Fig. 13.

Hind leg of male Onion Fly (1) and of male Cabbage Fly (2); much enlarged. Original.

1. *Ground Tobacco:* to be dusted liberally around the plants on the surface of the ground. Is intended as a repellant, must be in place before the eggs are laid and must be renewed at short intervals until all flies have disappeared. It was also desired to learn whether the leaching from the ground tobacco would kill the young larvæ provided any hatched before the tobacco was in place.

2. *Powdered White Hellebore:* to be used like the ground tobacco as a preventive, but also as a killing agent in the form of a decoction of two ounces of the powder steeped in one gallon of hot water. Applications of the decoction at the rate of three to four ounces per plant whenever maggots were actually present.

3. *Carbolic Acid Emulsion:* make into an emulsion one pound hard or one quart of soft soap, one gallon of hot water and one pint of carbolic acid. Dilute for use with thirty parts of water. This is a killing agent and was to be applied whenever maggots were present on the plants.

4. *Scalecide:* a killing agent, to be used like the carbolic acid emulsion at the rate of one to twenty-five. This is a petroleum preparation that had never been used against underground insects, and it was desired to learn of its effect on them and on the plants themselves.

5. *Kerosene and Sand:* a large cupful of kerosene to a pail of dry sand, well mixed and applied on the surface around the base of the plants to be protected. It is a repellant and should be in position to prevent the fly from laying eggs.

6. *Kerosene Emulsion:* to be made according to the usual formula of one-half pound soap, one gallon of water, two gallons of kerosene. Dilute for use with twelve parts of water and apply as a destructive agent whenever maggots are present on the plants.

7. *Exposure:* remove the soil from the base of cabbage plants as soon as they are well rooted and allow a long stem to be exposed for a week so as to toughen it. Then hill up around the plant and pack well. The suggestion is that if eggs are laid on the toughened stem the young larvæ will not be able to penetrate it and will die. Must be done before any flies are in the field.

8. *Tar paper disks:* round disks so cut as to fit around the stem of a cabbage plant at the surface of the ground and intended to prevent the flies from getting at the place where the eggs should be laid to give the resulting larvæ a fair chance for life.

The following growers agreed to use and report upon one or more of the materials above named:

Mr. Howard G. Taylor, Riverton, Burlington county.
Mr. Arthur P. Seabrook, Husted, Cumberland county.
Mr. L. H. Stemler, Matawan, Monmouth county.
Mr. Geo. E. Woodward, Windsor, Mercer county.
Mr. E. C. Ryan, Bakersville, Atlantic county.
Mr. Edwin R. Adams, Bakersville, Atlantic county.

Fig. 14.

Riverton Experiments, May 21. At the left a view of the cabbage rows infested with maggots at the right a nearer view of the rows, with dying plants. From original photos.

Fig. 15.

Riverton Experiments, June 8. Views across and parallel with the cabbage rows to show the large percentage of infested plants. From original photos

Ground tobacco, powdered white hellebore, carbolic acid and scalecide were furnished to all those that used these materials. We could get no one to try the paper disks. Complaints of injury and offers to try experiments were received after the insects began to appear in the fields, but practically always so late that by the time application could be recommended and made they were too much delayed to be effective.

Mr. Dickerson was assigned to arrange for and to watch the experiments, but as it was desired to make this largely a growers' trial, all the applications were made by them and at times selected by them except as otherwise noted here. The results, while they seem at first sight disappointing, were really not so when closely studied, and they give material for practical recommendations which will be made in a bulletin on the subject. It is desired here to record only the experiments made to show the varying conditions and results.

Riverton Experiments.

April 25th, Mr. Dickerson found that Mr. Taylor had set out five rows of cabbage plants solely as subjects for this experiment. One row was to be used as a check, the others divided into one-half rows were to be used in the experiments. The first application of tobacco and hellebore was to be made on the 26th.

May 21st, maggots were found in considerable numbers on both treated and untreated rows, and at first sight the latter were no better than the former, but on search many places were found in the rows treated with carbolic acid and kerosene emulsions which showed maggot attack while the insects themselves were gone. Neither the tobacco nor the hellebore had, apparently, served as a repellant. The scalecide had injured the plants and had not, apparently, killed the insects. The carbolic acid emulsion had been used at half strength only through an unfortunate misunderstanding, not due to Mr. Taylor, and the test was not a fair one. The difficulty seemed to be largely mechanical; many of the maggots were very low down on the roots, while others seemed to be covered by an exudation that acted as a protection.

June 8th, the larvæ had very generally changed to the pupal stage and many of the flies had emerged, so that the experiments, as against that brood, might be considered closed. All the plants

were set April 30th, and each half row or experimental unit contained eighty-five plants.

No. 1. *Ground tobacco* was thoroughly dusted around the plants May 11th, 18th and 21st. On this series twenty-two plants were destroyed by the maggots. The application intended for April 26th was not made, and it is probable that this omission materially affected the result.

No. 2. *Powdered white hellebore* was used, like the tobacco, May 11th and 15th, and on May 18th and 21st it was used as a decoction—two ounces to one gallon of water, a teacupful to a plant. Seventeen plants were destroyed by the maggots. As in the previous case, something was lost by delay.

No. 3. *Carbolic acid emulsion* was used at the rate of one-half pint to twenty-five gallons, May 15th and 18th, and at the rate of one-half pint to twenty gallons May 22d. The applications were too late and too weak and thirty-eight plants in the series were destroyed by the maggots.

No. 4. *Scalecide* was used at the rate of one to twenty-five of water, May 15th, 18th and 22d. Some injury was caused to the plants, and apparently there was little or no effect as against the insects. Sixty-seven plants in this series were destroyed by the maggots or by the added injury due to the insecticide.

No. 5. Exposure was tried on this series, *i. e.*, the earth was removed as described in the outlined plan, but infestation was so obvious that the carbolic acid emulsion, one-half pint to twenty-five gallons, was applied May 18th and 22d. On this series thirty-seven plants were destroyed by maggots.

No. 6. *Check Row* was so generally infested May 22d that hellebore decoction, six ounces to one gallon of water, was used. Thirty-three plants on this series were destroyed.

No. 7. *Kerosene and Sand* were applied May 15th and 22d, as described in the outlined plan. On this series twenty-nine plants were destroyed.

No. 8. *Kerosene emulsion* was used at the rate of 1 to 12 of water May 15th and 18th, and at the rate of 1 to 10 May 22d. On this sixty-eight plants were reset. Oil injury was undoubtedly responsible for the death of some of these plants.

No. 9. *Check Row*, no application; forty-seven plants were destroyed

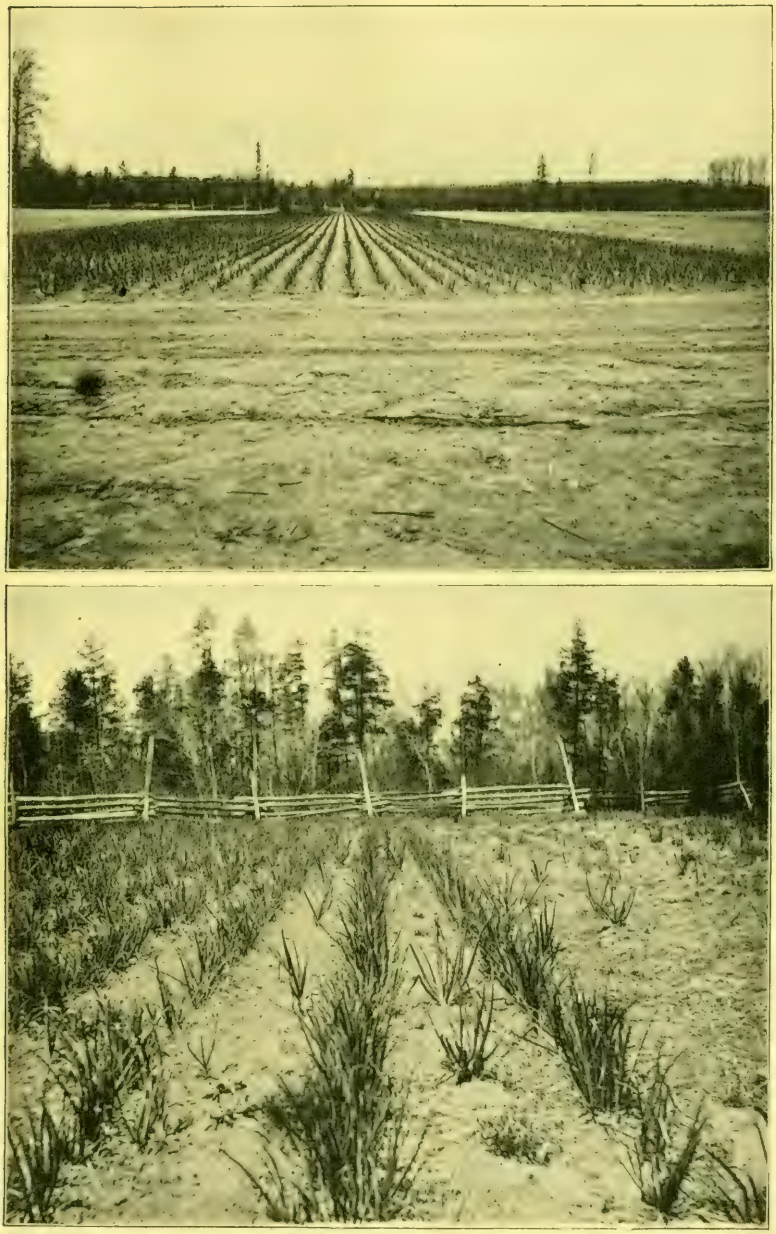

Fig. 16.

Husted Experiments, April 23. Above is a bed of onion sets, in good condition. Below is a bed of "scallions." The straggling plants between the rows show the location of the rows destroyed in October, 1905; the present good rows being planted after the original rows were killed off. From original photos.

Fig. 17.

Husted Experiments, May 26. To the left, five rows of turnips so injured as to be plowed up. To the right, a bed of radishes abandoned after a few pickings. From original photos.

No. 10. *Check Row,* no application; forty-one plants were destroyed.

Expressed in tabular form, we have it as follows:

Material.	*Plants Lost.*	*Material.*	*Plants Lost.*
Tobacco	22	Check and carbolic acid	33
Hellebore	17	Kerosene and sand	29
Carbolic acid emulsion	38	Kerosene emulsion	68
Scalecide	67	Check	47
Exposure	39	Check	41

Placed in this way, the only materials for which any obvious advantage can be claimed are tobacco and hellebore. The kerosene emulsion and Scalecide make a frightfully bad showing, while the kerosene with sand stands third in the list of plants lost.

On a general inspection throughout the territory around Riverton, Mr. Dickerson found that the maggot had taken anywhere from one-third to one-half the plants on almost every plantation. Based on this general rate of infestation, only the hellebore and tobacco showed any decided benefit.

An obvious criticism is that the experimental applications were begun too late, and that none of the material had an opportunity of acting on the very young maggots, where their effectiveness might have been at the maximum. The carbolic acid emulsion was, as already stated, too weak to be of any use except against the smallest larvæ.

Husted Experiments.

April 23d, Mr. Dickerson found on the Seabrook place onions in almost all stages of growth; just germinating from seed sown a few days before; sets that had sprouted three to four inches, and "scallions" ready for sale. The field of scallions had been sown in September to be ready for March; the young plants were almost completely wiped out by maggots; new seed was sown in October, and the scallions are therefore a month late, but free from maggots. The adult onion fly was observed among these plants.

May 26th, an examination of conditions showed that the tobacco and hellebore had been used on May 8th and 15th, and the kerosene emulsion, Scalecide and carbolic acid emulsion on May 23d. Rows of onions growing for sets, and others growing from sets, were found to be quite as badly infested where treated with the ma-

terials as when untreated. The story was repeated on the turnip, radish and cabbage patches, and apparently all the applications were complete failures. The preventives, however, were applied too late, because the flies were already seen April 23d and the first application was not made until May 8th. So the carbolic acid emulsion was not used at sufficient strength, nor until the insects were so well grown that many of them were protected by the contracting skin or in the plant tissue.

June 12th, another visit was made and a very careful investigation was made of the onion-growing practice and how the maggot affects it. It was found that the latest applications of the carbolic acid emulsion made at the proper strength had been effective in killing the insects, though too late for much practical result, and most of the insects were then in the pupal stage or already changed to adults.

Mr. Seabrook has been one of the heaviest, if not the heaviest, sufferer from maggot attack in the State, the actual money loss for the season being not less than $1,000. Large areas of radishes were plowed up before even a small percentage of the crop had been marketed, a field of turnips was totally lost, cabbages were in nearly as bad condition and the onion crop had been seriously diminished in value. His experience has been unfortunate for several years past, yet it has also given a clew to what may prove to be a practical method of control, as will be developed later.

Matawan Experiments.

April 27th, Mr. Dickerson visited Mr. Stemler to arrange with him concerning the experiments to be made against the onion maggots. Several rows had been sown that were not yet up, and on the plants up from seed sown in cold frames no signs of the flies could be found. Mr. Stemler agreed to try most of the experiments and some of his own in addition, so it was left to him to arrange as he chose.

May 19th the place was again visited: the plants from seed and cold frames were all in good condition, but adults were observed on the plants and on the wing. No maggots were found on search at this time, although Mr. Stemler said he had found one in a plant earlier in the day. All the preventive materials had been

applied according to directions, and, in addition, carbolic acid and slaked lime had been used on the older plants.

June 7th, Mr. Dickerson made a final examination and found that there had been very little feeding in the onion patches, the only sufferers being on the outside or check rows. One row was devoted to each of the experiments and the remainder of the patch was treated with the lime and carbolic acid. Mr. Stemler's place was badly infested last year (1905), and this year (1906) the infestation was so slight that it was scarcely noticeable, while neighbors on either side of him have badly infested plots. The plantations of 1906 were not far from those of 1905, so that distance could not be responsible for the exemption; besides, flies were actually observed on the onion plants May 19th. Mr. Stemler furnishes details of the applications made.

Tobacco, white hellebore, kerosene and sand, one row each; kerosene and sand was made by adding one pint of kerosene to eight quarts of sand.

First application was very freely applied just before the onions came up.

Second application was made *three* days later. This and all the following were somewhat lighter than the first application.

Third application was made *five* days after the second.

Fourth application was made *seven* days after the third.

Fifth application was made *seven* days after the fourth.

Sixth application was made *seven* days after the fifth.

Seventh application was made *seven* days after the sixth.

In each case the material was put on while the plants were wet with dew.

Scalecide, carbolic emulsion and kerosene emulsion were used as killing agents, each on one row. Scalecide was used 1 to 25; carbolic emulsion was used 1 to 50; kerosene emulsion was used 1 to 12.

First application was made just as soon as the onions were fairly up.

Second, third, fourth and fifth applications were made at intervals of seven days between each.

In the field, the first, fifth and ninth rows were left as checks, where no remedy was applied. On all other parts of the field outside of the experiment and check rows, lime and crude carbolic

acid was applied once each week for four weeks, beginning just after the plants were up.

The mixture was made by slaking lime and leaving it quite thick, using one and one-half quarts to one gallon of water and one teaspoonful of crude carbolic acid.

The Scalecide and kerosene emulsions proved injurious to the growth of the onions. The first fly was seen May 13th. The first maggots were found May 24th in the check rows, where nothing was used, and also in the row on which Scalecide was used. In the other parts of the field no maggots were found.

No fly was to be seen after the crude carbolic applications were made, and the odor of the acid was perceptible several days after each application.

Mr. Stemler claims that as the result of his observations the carbolic acid emulsion before the plants are up and the lime and carbolic acid mixture after they are up should be used to "exterminate" the onion maggot.

White hellebore and tobacco dust are also good, but should be applied very freely before the onions are up, and also every time it rains afterward.

As compared with the previous experiments, the one just recorded is remarkably successful, and it should be noted that, as compared with the others, this latter one began before the plants were actually up, and the applications were continued at intervals of a week or less for a month.

Other Experiments.

The applications at Bakersville and at Windsor were inconclusive because the maggots were so scarce that even untreated plots remained free from attack, and no basis for comparison existed.

No recommendations for actual practice are made at this time, but growers are invited to study Mr. Stemler's results based on early and frequent applications of whatever material is used.

THE PERIODICAL CICADA.

Tibicen septendecim.

Just seventeen years ago I wrote in my first Report as Entomologist to the Experiment Station: "There will be many who contend that the insect appears every few years and that the seventeen-year period is only imaginary, while others who have observed them in one locality only will ridicule the assertion that they are met with in any years but those shown on their own records." At that time also I listed the broods known to occur in New Jersey and gave their distribution as shown from the records.

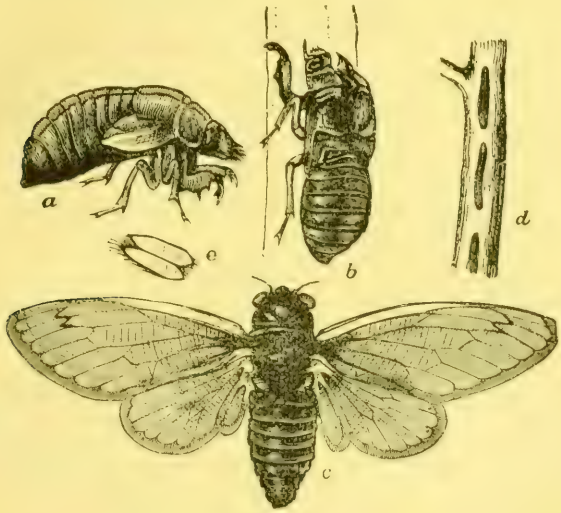

Fig. 18.

The Periodical Cicada: *a*, pupa ready to change; *b*, empty pupal shell; *c*, adult; *d*, cavities to receive eggs; *e*, eggs, enlarged.

Every brood then listed has appeared on schedule time, and in my Reports for 1894, 1898 and 1902 will be found accounts of the broods occurring in those years. Since 1889 our knowledge of this insect has increased so that instead of twenty-two broods known at that time we now record thirty, as worked out by Mr. Marlatt in circular 45, second series of the Entomological Division, United States Department of Agriculture.

Brood No. VIII. in my Report for 1889 is now No. XIV. of Marlatt, and its distribution was given as "the southeastern part of Massachusetts, across Long Island, along the Atlantic coast to Chesapeake bay, and up the Susquehanna at least as far as Carlisle, in Pennsylvania; also in Kentucky, at Kanawah in West Virginia, and Gallipolis, Ohio, on the Ohio river." No definite localities were then known in New Jersey, but as the results of my investigations, four points were established: Englewood, Bergen county, along the Palisades; Princeton, Mercer county; Palmyra, Burlington county, and Red Bank, in Gloucester county. This makes a diagonal but disconnected line across the State, and nowhere did the insects occur in any numbers.

My experience with the more recent broods and the observations made of the deadly warfare waged by the sparrows on these insects inclined me to the belief that the brood would appear in greatly reduced numbers during the current year, if at all, and I therefore asked a large number of the office correspondents to keep a lookout for the species, and to send in reports and specimens should any occur in their locality. The members of the Brooklyn, New York, Newark and Philadelphia Entomological Societies were also asked to co-operate, and the office staff was charged to observe any signs of the insects' presence and to question farmers everywhere.

The result was entirely negative; not a single specimen was received from any locality within the State; not a sign of their presence was noted, and all reports of their occurrence when investigated proved to be unfounded. This brood seems to have been completely eliminated, or so greatly reduced in numbers that nothing was seen of it. On Long Island and in Pennsylvania the insects appeared in their usual numbers, and I believe that in other parts of their range they were also observed. On Staten Island a few pupa shells were found, indicating that the insect did appear there.

Mr. Dickerson, in the course of his inspections of orchards and nurseries, covered the entire ground of its appearance in 1889 and made special trips to Englewood and to the woodland area between Princeton and Rocky Hill during the period of their usual occurrence. Nowhere did he find any trace of the species.

It is more than probable that the remaining broods will become less numerous at each appearance as the forests are cleared and as

Fig. 19.

Effect of windstorm on Newark shade trees. Above, an old tree with decayed trunk blown over; below, branches torn from trees in Military Park. From original photos.

the sparrow domination increases, but it will be many years before this interesting species disappears from our fauna. Its absence this year was not unexpected, because in 1902 I wrote: "The brood is a small one, the area of its appearance is limited in well-settled regions, and it is doubtful whether in 1906 it will be noticed at all."

SHADE TREE INSECTS.

Attention has been called to the fact that increased interest has been and is now being manifested in city shade trees, and that Bulletin No. 181, dealing with the insect enemies of such trees, has been in constant demand, until now very few copies remain. The municipalities that began work in the recent past have continued their operations and have increased them in extent, while others have either begun work or have manifested a desire to do so. In a greater number of cases individuals or bodies of individuals have taken up the matter in smaller cities, towns and villages, and in all cases where applications were made to the office prompt attention was given and such recommendations were made as seemed to be demanded. In every instance it was made clear that it was the desire of the office to co-operate to the extent of its ability.

Newark.

The most complete organization for the care of shade trees exists at Newark, where the work is in the hands of a shade tree commission with large powers and a liberal appropriation.

April 13th, Mr. Dickerson went over the city, in a general way, with Mr. Carl Bannwart, the secretary of the commission, who is in general charge of the field work. It was found that as to the cottony maple scale the prospects were that it would be present in much smaller numbers than in 1905, although locally there were trees as badly infested as at the same period last year. This was offset by other localities in which the natural enemies had made an almost clean sweep, and almost everywhere conditions were much improved.

Oyster-shell scales were present in numbers on some poplars and other trees, and an *Aspidiotus* on maples was obvious in some places.

July 11th, after the heavy windstorm of the day before, Mr. Dickerson again went over the ground with Mr. Bannwart and examined more particularly the broken branches and limbs that everywhere testified to the force of the wind. The work of the wood leopard moth was in evidence everywhere, and particularly on elms and soft maples, the weakening of the branches caused by their borings being responsible for a large proportion of the breakage.

As to general insecticide work, the spraying was done with a combination of arsenate of lead and Bordeaux mixture at the rate of ten pounds in one hundred gallons of water, and that did not seem strong enough to kill the nearly mature caterpillars of the tussock moth, though it did appear to make them sick and to hasten their descent from the trees. This and the elm-leaf beetle have been the most troublesome species, though the beetle was not as abundant as it was at New Brunswick. The insects have been kept in check pretty well, however, in the parks and on the main streets, but on some of the side streets here and there were a few bad trees, because it was simply impossible to get everywhere in time.

October 20th, Mr. Bannwart wrote me, in response to my request, a summary of what had been done, which is as follows, omitting some irrelevant details:

The most troublesome pests which afflicted our young elms were the elm beetles. Our spraying during the first of the season was very successful, but in two subsequent sprayings we did a great deal of harm. As soon as I found, after the men had worked two days, that the leaves were being injured, I stopped the spraying with that insecticide; but most of the elms had been gone over in that time and a great many of them had lost their leaves. We, of course, do not want to give up to the elm-leaf beetle. We expect to spray early in the season next spring with a hope of killing the adults. I have not noticed any great injury resulting from their work on the large elms.

The insects second in importance were the tussock moth caterpillars. We protected the park trees against them absolutely. The work on the street trees was at least 75 per cent. better than last year, and there were no small trees defoliated by them. We creosoted the egg-masses preparatory to the second brood, and

found this absolutely effective. In the spraying we used arsenate of lead almost exclusively. In the first part of the season used the Bordeaux mixture with the arsenate of lead, using about ten pounds of the latter and eight pounds of the former in paste form, with lime, to one hundred gallons. There seemed to be a tendency for one mixture to neutralize the other—at least in color—so that we could not see the mixture on the leaves.

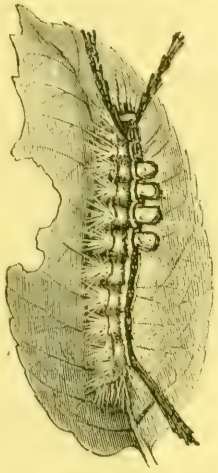

Fig. 20.
Caterpillar of Tussock Moth. After Riley.

The tussock moths were more numerous than usual, but our spraying operations have been in proportion to their increase, and the campaign showed that their rise and fall were absolutely in our control. This confidence is emphasized by the additional ability to fight them in the egg and pupa stage.

On the whole, the spraying operations were satisfactory in connection with the tussock moth caterpillar and not satisfactory in spraying for the elm-leaf beetle. This may be because the elm beetles were more noticeable on the younger trees and the leaves were more tender.

It may be well to say in this connection that in purchasing insecticides for the use of the commission, the desire to give local competitors an opportunity to supply part of the outfit resulted in obtaining a lot of imperfectly-prepared material with a large percentage of free arsenic. It is not likely that this mistake will be repeated. That the elm beetle is not in itself so difficult to keep in check is proved by our experience at New Brunswick, where it was much more plentiful than in Newark, and a record of this experience finds a fitting place here.

The Elm-Leaf Beetle.

This insect, after a series of years during which little was seen of it in New Brunswick, recovered its ground during the season of 1905, which was favorable to it, and great numbers of the adults went into hibernating quarters in good condition. This fact noted led to the belief that it might prove injurious in 1906, and preparations were made for spraying the trees on the college campus in

Fig. 21.

Elm-leaf Beetle: *a*, *a*, patches of eggs on leaves; *b*, larvæ feeding; *c*, adult; all natural size; *d*, egg mass; *f*, surface of egg; *g*, larva; *h*, *i*, larval details; *j*, pupa; *k*, beetle; *l*, surface of elytra; all enlarged. From Rept. Ent., U. S. Dept. Agl.

the spring of 1906. With the unfolding of the leaves the beetles appeared in numbers, and as soon as the first egg clusters appeared the trees were thoroughly sprayed with arsenate of lead at the rate of about five pounds in one hundred gallons of water. The object was to kill off as many of the adults as possible before they had a chance to oviposit, and this was very largely accomplished. On some favorite trees, however, so many egg clusters were found that

Fig. 22.

it was deemed wise to re-spray them as soon as the first larvæ were noticed.

The result was all that could be reasonably desired. A large proportion of the trees were practically unharmed, while none were sufficiently injured to cause a dropping of leaves or any marked disfiguring. This was in strong contrast to other elms in the vicinity, which were completely defoliated before midsummer and did not become recovered until fall, when a second crop of foliage was made.

Three different makes of arsenate of lead were used, ranging in price from thirteen cents to eighteen cents per pound, and so far as results were concerned, no difference was noted. In no case was there any burning of foliage, no matter how excessive the application, and in all cases the foliage was protected during the entire season.

The object of the record was not so much to determine the killing power of the poison, for that has been sufficiently demonstrated, as to show that practically large trees on a limited area could be completely protected while unsprayed trees around about were badly injured. It was further intended to show that even a single spraying might be sufficient to protect, provided the application was made early enough, or before eggs were deposited. It is probable that it was not really necessary to spray a second time even those trees on which egg clusters were present in numbers, but as there had been a day of rain just after these trees were first sprayed, it was deemed wiser to take no risks.

East Orange.

This city also has a shade tree commission as complete in its organization as that of Newark, and second to it only in the extent of its operations. The secretary and superintendent of this commission is Mr. William Solotaroff, and he has handled a somewhat different problem equally well. At my request he has furnished a summary of the work of the season of 1906, as follows:

"The insect that gave us the most concern this year and last was the *Pseudococcus aceris* on the sugar maple. In 1905 it was a pest here of the worst form. On August 1st, 1905, we sprayed the trunks and main limbs of some of the trees, and I found that the

larvæ and the adults were killed, but that the cocoons, in which state the insects largely were, were not penetrated. On August 23d began the treatment of the sugar maples by dry brushing. One man with a house broom cleaned the trunk to a height of about eight feet; another man with a bristle brush, fastened to a twelve-foot pole, cleaned to a height of about fifteen feet, and a third man with a hand brush and ladder cleaned the rest of the tree. By this means every sugar maple in East Orange was brushed. Some larvæ escaped, and I waited until the leaves fell and the larvæ of the last brood took to the trunks, and then I sprayed the trunks and main limbs of the trees on several trees with Kill-O-Scale. During the winter the trees showed little trace of larvæ, but this spring I noticed that some of the trees were covered with a few larvæ again. On August 6th of this year we began washing the trunks of the sugar maples that showed some scale with Kill-O-Scale, 1 to 20, and treated the trees on about half a dozen streets that had a predominance of sugar maples. The result has been that almost no females were found on the leaves in the latter part of the summer and no leaves fell, as had been the case of the year before. The trees are clean now."

"The cottony maple scale I found was present in very small numbers. The trees that were treated by means of the solid jet of water to break up the egg clusters in 1905, as explained to you before, showed almost no adult females when examined this spring. Some trees on other streets showed the insects more numerous, but not in sufficiently large numbers to make it necessary to do any fighting against them.

"The tussock moth was present in very small numbers. The two pickings of egg clusters of the two broods in 1905 seemed to have cleaned them. On June 13th began spraying with arsenate of lead some linden trees that we had set out in the eastern section of the city and collected egg-masses on some larger trees in that part of the town. There was no appearance of the second brood in any way to call for work against them.

"The elm leaf beetle was present in a general way all over the city, but not as a very bad pest, excepting on some trees here and there. On July 9th began to spray the elms on a few streets with arsenate of lead. Of course, there was not much that could be done at that time, as the insects were near the time of pupation, and all the damage had been already done.

"The fall web-worm and the bag-worm were present in some numbers, especially the web-worm. The latter was especially numerous on the wild cherry and in gardens on fruit trees. The only combating of the web-worm that came under our charge was on a street of Oriental planes that we had planted. We cut out the twigs that were infested and burned them."

Montclair.

Montclair has no organized shade tree commission, and the task of keeping the trees in condition is imposed upon Mr. Malcolm H. Smith, superintendent of roads and sewers. This task is really very well performed, all things considered, and Mr. Smith keeps in communication with the office, while occasional inspections are made by one or the other member of the office force.

June 28th, Mr. Dickerson, at the request of a committee of the council appointed to investigate the condition of the shade trees, made a rather careful survey, accompanied by the members of the committee, and later presented a full report showing what was observed and making suggestions as to what could and should be done to keep the town trees in health and vigor and free from insect pests.

August 20th, he made another visit, at the request of the superintendent, and found a local infestation of the pigeon *Tremex* on red maples, as well as some injury due to bark beetles.

At those places where the cottony scale was so very abundant last year and the year before only isolated examples could be found, and not many of those. Everywhere the work of the *Coccinellid* was in evidence, and very few survivors remain to continue the species. The *Pseudococcus* was almost equally well in control, and occurred nowhere in obvious numbers. On the whole, conditions were favorable, and the trees generally were in good shape, so far as insect infestation is concerned.

Hoboken.

This city also lacks organization for keeping its trees in good condition, but the council did go far enough to employ Messrs. Bobbink and Atkins, of Rutherford, who give essentially the following account of their doings:

We sprayed the trees in the parks in the city of Hoboken principally for the tussock moth caterpillar. The remedy that we used was arsenate of lead, and the results were more than satisfactory. We used a Field force pump with a one-hundred-and-fifty-gallon tank, and about eight pounds of the arsenate to the one hundred and fifty gallons, though we believe that a less amount would be quite efficacious. We do not believe there is another city in the United States, and we say this without reserve, where the trees are in such a deplorable condition as in the city of Hoboken. It is quite an easy matter to pull off large cakes of the tussock moth cocoons and eggs a foot square. We only gave the trees one application at just about the time the caterpillars were commencing to feed, and we strongly urged the council to give us an opportunity to give the trees a second application when the second batch of caterpillars appeared, but unfortunately they allowed this to go by default.

For San José scale we have used "Scalecide" to splendid advantage; in fact, it is the best thing we have discovered up to date. We have also used "Horicum" with equally good results.

In treating the trees of the town of Rutherford we sprayed principally for sucking insects, and used an application of whale oil soap, with a small proportion of tobacco juice added. We were quite pleased with the results of this application.

We find that there is now being quite an interest manifested in the preservation of the trees in most towns, and we believe this is brought about through the efforts of the Experimental Station and the shade tree commissions.

We have worked on the basis of $25 per day for our outfit, but there is little profit in it at that rate, and we propose to increase our charges to from $30 to $35, according to the caliber of the trees which we may have to treat. We believe that orchard spraying can be done for as low as $10 to $12 per day, and where a farmer owns the machine for a good deal less.

Rahway.

Rahway has no organization for shade tree work as yet, but at the request of the street commission, Mr. Dickerson made an examination of their shade trees in March and reported upon the

conditions found. The city trees are largely silver and soft maples, and last year the cottony scale was exceedingly abundant. At the time of the inspection the remnants of last year's adults were still in evidence, and among them were a number of hibernating, living examples. There was evidence that the *Coccinellid* had been at work, and it was believed that it would be safe to predict the control of the pest within a year or two at most.

Other Towns.

No systematic record was kept of places where assistance or information was given by correspondence only, but there were a number of them, and largely from the coast towns, where much tree planting is now done.

In *Jersey City* an inspection was made September 6th at the request of a property-holder and it was found that a series of small, recently-set trees were dying off—maple, poplar, plane, etc. These had all been banded about five feet above ground with tar, and cotton tied over this. The banding was only a few inches wide, and was done in the spring of 1905. The trees began dying only a few weeks previous to the inspection, and this was due to the tar band. This, according to Mr. Dickerson, acted in two ways: First, the tar hardened and prevented the expansion and increase of the bark and tissue, and second, the tar had apparently penetrated the bark and underlying tissue and killed it. This was fully borne out by the examinations made, and removal was advised, although the trunks were alive below the girdling and some new shoots were being made.

At *Morristown*, inspections were made by Mr. Dickerson June 5th and July 14th, at the requests of individuals whose trees were showing signs of injury, and advice was given in both cases. In the one instance sugar maples that were badly infested with the *Pseudococcus* had been painted with undiluted crude petroleum, and these were dying, and later died. There is no doubt that the oil killed them, although it tested forty-four degrees, as shown by samples received at the laboratory, and although other trees of similar varieties and age had been safely treated in previous years.

At *Mountainside* the "Union County Tree-Spraying Company" has established itself and is doing considerable work in the neighboring towns, villages and their gardens and streets. It has a neat tag which is attached to each sprayed tree, giving date of application and material used.

Altogether, this branch of the work of the office has not been neglected and has been of distinct importance.

THE SIGNATE LADY-BIRD BEETLE.

In those cities in which the cottony maple scale or *Pulvinaria* was most abundant during 1905, it was noted that the natural enemies were also increasing in proportionate numbers, and it was predicted that during 1906 the infestation would be much less, if not entirely cleaned up. The most important agent in this work was without doubt the signate lady-bird beetle, *Hyperaspis signata*, which was figured and described in the report for 1905. In order to follow its work and its relation to the host, Mr. Dickerson was instructed to watch it on his visits to the infested cities and towns and in New Brunswick, which he did.

Fig. 23.

The Signate Lady-bird, *Hyperaspis signata*; enlarged. Original.

It was first seen in New Brunswick about the middle of April, on the trunks of sugar maples infested with the *Pseudococcus*. The latter were at that time moving around on and crawling up the trunk, and this leads to the suggestion that they might be destroyed in large numbers by winter spraying with a soluble oil, supplemented in early spring by a sticky band, say of "tanglefoot," at the base of the branching, which would prevent the infestation of the tree above.

The beetles, when observed, were probably fresh from their winter quarters and resting quietly on the bark, and some examples, with a number of the *Pseudococcus*, were taken to the labo-

ratory. Next day these were observed feeding on the *Pseudococcus* in the same way that other specimens had been observed feeding on the larva of *Pulvinaria* in 1905. April 26th, and on several succeeding days, more beetles were seen on the infested trees, but after May 4th they disappeared and were not again seen.

On trees infested by *Pulvinaria* no beetles were seen in New Brunswick, but no very close examinations were made, and as the infested branches were well out of reach and the lady-birds are very active they might very easily have been, and probably were, present.

On May 8th the lady-birds were observed both at East Orange and Montclair, but not in large numbers. In East Orange the work of the shade tree commission, in some places, and the work of the beetle, in others, had reduced the *Pulvinaria* to harmless numbers, and in Montclair the beetle, supplemented by the little parasitic *Coccophagus,* had wiped it out almost altogether. In all the localities where examinations were made the beetle had done good work against the soft scale.

In 1905 the beetle was but rarely observed on trees infested with *Pseudococcus,* but during the present year it was observed wherever this scale was seen, and often the larva was found imbedded in the cottony mass of the adult female, where it was as well concealed as in the *Pulvinaria*, but the pupæ were not so well protected and undoubtedly occurred on the undersides of the leaves and in similar situations.

Fig. 24.

Twig with cottony scales torn and eaten by the Signate Lady-bird; slightly enlarged. Original.

July 5th, the lady-bird was observed feeding on the tulip soft scale, *Lecanium tulipiferae*, near Summit. Several badly infested trees were found and on all of them the adult beetles as well as larvæ were present. In this case there was no protection for any stage and the pupæ were found on the undersides of the leaves or resting in and partly concealed by the rough bark.

Fig. 25.

Larva of Signate Lady-bird; much enlarged. Original.

The beetle larvæ undoubtedly destroyed many of the scale larvæ, but were actually observed feeding only on adults. In this case they did not get within or under the scale, but rested at its side, and apparently sucked out the body juices through a puncture. A similar method of feeding was observed in an allied larva later in the season. This was feeding on plant lice, and was seen to hold on by a leg which had been punctured, while under a lens the body juices of the louse could be seen running down and passing into the mouth cavity of the larva. Small scale larvæ may be eaten entire by the larva of the *Hyperaspis*, but of large specimens only the juices are absorbed.

The interesting point in these observations is that whereas in 1905 the lady-bird beetle and its larva were found feeding almost exclusively on the cottony scale, *Pulvinaria*, in 1906, when the latter was absent or rare, the *Pseudococcus*, and even the *Lecanium*, were attacked and used as substitutes. The *Pulvinaria* is undoubtedly the normal food, and it will be interesting to observe whether in its practical absence the beetle will maintain its numbers on the other scales, of which the tulip soft scale at least is troublesome enough to need an effective check.

SAN JOSE SCALE.

This insect continues to demand a very large share of attention, but while it is still dreaded, it is no longer the terror and potential barrier to fruit culture that it was for a time considered. There is no doubt that thousands of trees have been killed and that thousands of trees will yet die from its attacks, but it is equally true that many of these thousands of trees died as much from neglect as from scale attack, and that other infested thousands will die in the same way. During the past year Mr. Dickerson and myself have visited every orchard-growing district in the State, and in one month I used one thousand miles of Pennsylvania mileage alone, largely in orchard work. We have seen every nursery and nurseryman in the State, and are in position to speak from personal experience concerning orchard conditions. It is my deliberate opinion that no more trees will be lost from injuries caused by the pernicious scale, provided the owner actively wishes to keep his trees. But the man who desires to plant trees and thereafter harvest crops without further effort will find the San José scale a frightful pest, and he will continue to rail bitterly at the entomologist who fails to provide him with a remedy that costs little or nothing and requires no effort to apply. It means work and intelligence and intelligent work to avoid injury, and the man who works most intelligently will succeed best as a fruit grower. It is

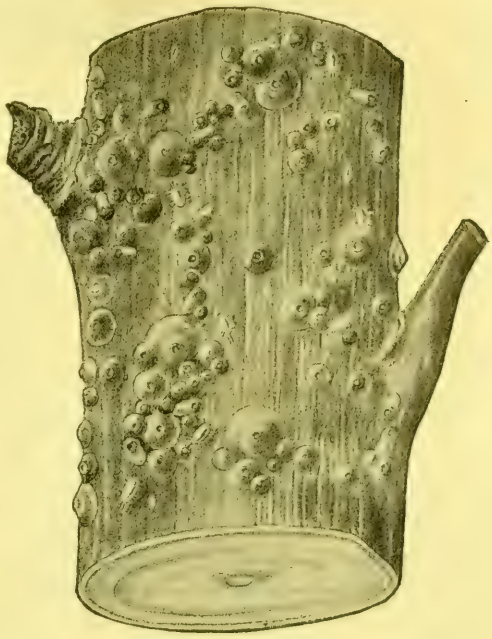

Fig. 26.

Section of branch infested by the pernicious scale; much enlarged. From Bulletin Virginia Station.

a pleasure to be able to say that a large percentage of all the active orchardists in New Jersey come up to the standard required by scale conditions, and a matter of regret that some orchards yet remain to men who lack either disposition or ability to care for them.

Mr. Dickerson, as the result of the orchard inspection work done by him as assistant to the State Entomologist, writes: "On the whole, the orchards are in much better condition, so far as the scale is concerned, than they were a few years ago, and I believe they will continue to improve. The majority of the growers who have any number of good bearing trees are spraying, and it is safe to say that few, if any, are setting out trees without the knowledge that they will have to deal with the scale—a point in which they are materially helped by the fact that the trees which go to them from the nurseries are generally clean. Many of the neglected orchards have died and have been removed, so while there are some here and there, they are not so prominent as they were a few years ago. This is well illustrated by conditions in one of the peach districts of Hunterdon county, perhaps the leading peach-growing section of the State. The orchards throughout this region became more or less infested; the growers at that time knew little about the scale; they did not believe the stories told of it, or believed it could not be controlled, and spraying was done in many cases tardily and ineffectively, or not at all. The result was that many of the trees were lost, and a few years ago dead orchards could be seen scattered throughout the region. Last summer in driving through this vicinity I observed few dead and dying trees. I found most of the orchards, many of which have been sprayed with lime, sulphur and salt, in very clean condition, and there are some fine young orchards coming on. Most of the growers are doing what they can to keep the scale in check, and there is an increasing feeling that those who do not should be compelled to do so.

There seems to be also a feeling that the scale is disappearing and reports have come that it is not so prevalent this year as last. It is true that for some reason varieties which are usually much infested are occasionally uninfested even among badly infested trees, and it may be that local weather conditions may have aided slightly in keeping the insect in check. It may be also that this feeling is due to the fact that most of the good trees are being cared

for, while the neglected ones are disappearing, so that as a matter of fact the actual numbers of the insect are smaller.

For the most part spraying has been done in the spring, and the effort is made, apparently, to spray late—say, during March or April. It is generally known that fall spraying with whale oil soap will kill fruit buds, and several have claimed that they injured tender growth on peach with the lime, salt and sulphur, if applied before the wood is fully mature. Moreover, it seems to be generally believed that where applied thoroughly in spring, the lime wash remains for a long time, forming a coat that prevents scale larvæ from setting in such places. This and the probability that the fungicidal effect is greater when applied in spring, form additional reasons for making the application at that time.

Yet I found numerous places where Scalecide had been applied in fall, and without apparent detrimental effect on the trees. This fall work is due largely to the recommendations in the Station Bulletin, which suggests that applications made at that time would be of greater effect because the insects are not so fully dormant.

Mr. Dickerson further notes a tendency to spray more than once, and says the above materials (lime-sulphur washes and soluble oil) have also been in some instances applied twice in one season, *i. e.*, once in the fall and again in the spring. There is a tendency to do this where the trees are badly infested, for it is realized that even with the best materials it is often difficult to clean a badly infested tree with a single application. In like manner, some orchardists have used different materials the same season; one in fall, the other in spring. He cites one of the leading orchardists of the State as an example and I wrote him directly on the subject. This gentleman has probably a greater number of fruit trees under his control than any other one man in the State, and his experience with the San José scale dates back almost to the time of its first appearance within our boundaries. He has used almost every material that has ever been suggested as valuable and has spraying outfits in as great a variety as are to be found in New Jersey. He is also growing more and better fruits than ever before and is setting out new orchards yearly. His reply, under date of November 8th, is as follows:

"Thee asks just what is responsible for my good results with the scale. My theory was this: The lime and sulphur works slowly—is not apt to kill all the scales on the terminal buds—

and after using it one is apt to have scaly fruit. The soluble oil works quickly—kills the top layers of scale, and in fact all the scale it hits. But it does its work and the first rain washes it off, and if one scale in one hundred is left, conditions are just right for it to multiply and take possession of the tree. So I conceived the idea of using, first, the Scalecide to destroy 99 per cent., and then the lime and sulphur to kill and check the 1 per cent., but I confess I was not prepared to see such wonderful success. Neither the Scalecide alone nor the lime and sulphur alone compared in satisfaction with the two together. What I wonder is, whether two applications of either agent would have been as effectual as the combination. I suspect not."

Mr. Dickerson's report answers the question in part. After referring to the above orchards and their condition when he saw them in midsummer, he adds: In like manner I examined large, bearing apple trees which had been sprayed twice with lime, salt and sulphur. They had been very scaly, but now, late in summer, were very clean. The same conditions existed and the same results were obtained with Scalecide. I find many growers willing to make two sprayings and who feel that it is necessary, especially where trees are badly infested or are very large. In all such cases I believe that two sprayings are advisable.

A peculiarity to be noticed in excursions through the fruit-growing sections is that while in one place the mineral oil is almost universally used in some form, in others some lime and sulphur combination is the favorite. Mr. Dickerson refers to this and gives a partial explanation: "The material used in a particular locality depends largely upon local conditions. In several places I found that some good, energetic man had taken the initiative, sprayed his trees thoroughly with some particular mixture and obtained good results. This had been an example to others in the community, who did similar spraying with more or less success, and so it came about that that particular material came to be used in that locality. The character of the mixtures, also, have largely to do with their use. The various oil sprays, for examples, are easy to prepare and apply; they spray nicely and cover well, and have no irritating effect upon the skin. For these reasons I find that many prefer to use them rather than the more troublesome lime, sulphur and salt wash, even though they have to do more spraying, and in some cases even though they had to spray twice."

Mr. Dickerson might have added that much also depended upon the position taken by the agricultural paper which was locally the favorite.

With the realization of the necessity for thorough work comes a modification of practice in other respects. In the case of large apple trees, especially, it is difficult to reach the higher branches with the spraying outfit possessed by the average farmer. As a result these branches have been cut back in some instances, the owner feeling that he would rather do this and spray the rest of the tree thoroughly than to leave the top poorly sprayed and more or less infested with live scales. Another tendency in the case of badly infested trees is to cut back severely and to treat what remains very thoroughly.

And this leads to a consideration of the outfits used. In the majority of cases it is a barrel pump with one or two leads of hose, and extension poles carrying one, two or three nozzles. The Mistry or Vermorel type is generally preferred to the Seneca or Bordeaux type, the former being almost exclusively used by those who prefer the oil sprays. There are quite a number of power sprayers, however, of one kind or another. The "Niagara" is well represented and has the advantage of being very easy to operate, giving plenty of power and a great uniformity of pressure. Most of those using it seem to feel satisfied, but some consider that the price of the gas makes it too expensive. Other growers are using gasoline engines, and where there are large trees, or a sufficient number of them, such an outfit seems advisable, and has the advantage of furnishing power for other farm purposes. As a matter of fact, there are several instances where engines of greater power than was actually needed for spraying were purchased that they might be utilized in other ways. There are a few geared machines in use, and these serve well enough for medium-sized or small trees set apart, but where large trees are to be treated, or much spraying is to be done from one point without driving, it is not altogether satisfactory, and the auxiliary hand pump which usually accompanies such an outfit must be brought into play.

Mr. Dickerson says further, as a conclusion, that it will be seen from what has been observed that good results have been obtained and failures made with each of the mixtures. In considering these results and comparing the mixtures, all the factors must be taken

into consideration, and in the case of the oils the actual amount of raw material used, *i. e.*, the oil, should be the basis of comparison. For example, one man may spray with a mixture containing 20 per cent. of oil and another may use one containing 15 per cent. only, and yet the man who uses the weaker mixture may get more actual oil on his trees in a drench than the other may get with a more sparing use, each giving a complete covering to the tree.

Conclusions and Recommendations.

It is a fair conclusion, from what has been said above and from the observations recorded under the insecticide headings, that any well-made lime and sulphur combination, with or without salt, and any of the well-tested soluble petroleums, will kill all the scales that are actually reached or covered by them. It is further apparent that no one application can be relied upon to do entirely satisfactory work, and that the reason for that is mechanical rather than lack of efficiency in the insecticide. None of the materials or mixtures, undiluted crude oil excepted, will penetrate through a dense mass of scales or into all crevices so as to reach all the insects on a badly-infested tree, and none of them kill unless they come into actual contact with the insects. The soluble oils, at 1 to 20, contain so small a percentage of actual oil that a very thorough application is necessary to reach all the insects with enough to be entirely effective.

The insecticides at our command are sufficient to control the scale, and the remaining part of the problem is the mechanical one of placing them where they can get a chance to act.

Based upon all the observations and upon these conclusions, peach growers are advised to use the lime and sulphur combinations, because they have a fungicidal effect as well, and because they seem to act as a general tonic to such trees. Where the trees are only a little infested, either a fall or a spring application may be made. A fall application will be somewhat more reliable to obtain the greatest insecticide effect; the spring application seems to give better results against troubles due to parasitic plant diseases. Badly-infested trees should be sprayed twice.

Apples and pears are better sprayed both fall and spring, whatever the mixture used, and on apples I would recommend the solu-

ble oil in preference. Pear trees, unless very badly infested (and the same is true of plums), will do very well with the lime and sulphur combinations, but pear trees seem on the whole to derive as great a tonic effect from the oil as the peaches do from the lime and sulphur, and therefore I advise the former if only one kind of material is to be used. Apples should have at least one spraying with oil to reach the scales near the tips, which are so guarded that they stand more than an even chance of escape from even two applications of the lime and sulphur washes, and if one kind of material only is to be used, I advise the oil.

No oil combination that contains less than 4 per cent. of actual petroleum in the spraying mixture can be depended upon, and upon that basis "Scalecide," "Kill-O-Scale" and similar combinations, which are really liquid petroleum soaps, should be used at the rate of 1 to 15 as a minimum strength. Those mixtures that are said to be emulsions, and for which a greater percentage of actual oil is claimed, should be used at a similar dilution, even though this may give a slightly greater percentage of oil, because, for some reason which is obscure to me, emulsions are not so effective as the "soluble" oils. The K.-L., properly made and applied, is equal in effect to the soluble oils when it contains 15 per cent. of actual oil, and the same is true of the mechanical mixtures of oil and water.

The lime washes cannot be satisfactorily used on trees that have been treated with undiluted crude oil or with a mechanical mixture containing a large percentage of crude oil, because the vaseline remnant on the surface prevents a proper adhesion; but they may be used after the soluble oils because these contain no vaseline remnants, and wash off or evaporate completely.

Rain within twenty-four hours after spraying is apt to interfere with the effect of any mixture except undiluted crude oil, but the lime and sulphur combinations rarely suffer much after they are once set.

Thoroughness of application is essential whatever is used, and there should always be force enough to drive the spray into every crevice and through the hairy covering of twigs, and this is especially true of the lime washes, which tend to form a coating over a crevice or depression, instead of penetrating into it.

INSECTICIDES.

Arsenate of Lead.

This material is meeting with increased favor each year because it may be safely used on so many plants on which no other arsenical preparations can be applied, and because of its adhesive qualities.

As originally proposed it was formed by dissolving arsenate of soda (four ounces) and acetate (sugar) of lead (eleven ounces), and combining the solutions. Both of these materials are readily soluble in water and when they were combined a very fine white precipitate was formed, which sank slowly to the bottom. This precipitate was the arsenate of lead. It was not necessary to wait for precipitation, but, when the dissolved materials were united, the combined mixture was poured into the spraying tank, with as much water as was recommended for the particular insect against which it was required.

A simpler way was to put the materials in the proper proportions directly into the spraying tank with as much water as was to be used, and then stir until all crystals were dissolved and everything was thoroughly mixed.

Very good results were obtained in this way, but various practical difficulties arose—the chemicals were not always of good quality, and the resulting mixture was not a proper combination: the prices varied and the farmer often paid altogether too much for his insecticide; and lastly, the work of mixing in proper proportion was too much for many of those who would otherwise have used it.

The result was that the manufacturers of commercial insecticides took the matter in hand and there are now on the market a number of different brands, made by as many different firms, but very different in appearance, consistency and price.

In the municipalities in which spraying work has been done, arsenate of lead is quite generally adopted because there is little or no danger of injuring foliage through the carelessness of the ignorant help that must be largely employed, and some of these municipalities, in advertising for bids, received widely divergent offers and some very questionable material. It became necessary this spring to spray the elms of the College Campus to prevent injury from the elm-leaf beetle, and in order to test some of the

leading brands side by side I ordered some sixty pounds from the Adler Color and Chemical Company, of New York (Eagle brand); fifty pounds from the American Horticultural Distributing Company, of West Virginia (Target brand), and fifty pounds from the Bowker Insecticide Company, of Boston, Mass. (Disparene). I paid for the Eagle brand twelve cents per pound (in one-pound cans), for the Target brand twenty cents per pound (in two-pound cans), and for the Disparene twenty-four cents per pound (in two-pound cans). The Eagle brand cans were uniformly overweight, the Disparene was almost exactly correct and the Target brand was uniformly underweight. The Eagle brand was a dry paste, while the other two were sloppy in consistency. This does not, however, mean more water, but the addition of glucose or some other product to increase adhesive qualities. All of these materials, be it said here, gave equally satisfactory results when sprayed at the strength of approximately five pounds to one hundred gallons of water.

During the summer Mr. Carl Bannwart, secretary of the Newark Shade Tree Commission, and in charge of the spraying work, had some difficulty with the material used by him, and sent in two samples for analysis, stating that he had no sort of guide as to the amount of arsenic actually present in the material, and could not, therefore, use it intelligently. One of these was supposed to be a straight arsenate of lead (Cooper sample); the other was a combination supposed to contain copper and to be a combined insecticide and fungicide.

I handed samples of all of these materials to the chemical department, including also a new product just sent in for trial, and received the following report from Mr. J. P. Street, Chemist to the Station:

Analysis of Arsenate of Lead.

Manufacturer.	*Water.*	*Arsenic Oxid.*
Adler	51.59	14.74
Cooper	41.65	13.10
Schoonmaker (with Bordeaux)	23.97	5.58
Bowker	41.50	15.34
Target Brand	57.62	12.14
Vreeland	44.67	20.12

No attempt was made to do more than determine, first, the actual amount of water in the sample, and second, the actual amount of arsenic oxid ($As_2\ 0_5$).

The Schoonmaker combination may be excluded from the comparison because it is not a straight arsenate of lead, but when used as an insecticide it should have at least twice the weight ordinarily recommended to obtain the desired effect. The water in this material is less in quantity than in any other of those tested.

Of the rest, the Target brand contains more water and less arsenic than any other sample, besides being short weight, hence gives less value for the price charged. The Disparene, which is most nearly comparable with it in consistency and actual composition, is full weight and has less water with more arsenic than any except the Vreeland sample. The Eagle brand, though apparently drier, really contains a large percentage of water, but no glucose or similar material, and an arsenic content not much below the Disparene. It is by all odds the cheapest of the brands regularly on the market, so far as they have come under my notice.

The Cooper product was a special order, and ranks above the Target brand, but below all others, in arsenic. I understand that the price was about thirteen cents per pound, making it somewhat more expensive than the Eagle brand, than which it contains less water.

The Vreeland sample has a very high percentage of arsenic, and is said to be a new process material. It has never been tested, and is not yet regularly on the market, but if it can be produced at a satisfactory price it will deserve the fullest tests.*

The point to be noted is that, excluding this Vreeland sample, it required over three pounds of the Disparene and over four pounds of the Target brand to do the work of one pound of a fair quality of Paris green, and that it will require nearly four pounds of Target brand to do the work of three pounds of Disparene.

For the convenience of purchasers every manufacturer should print on the labels a statement of the minimum quantity of arsenic contained in his product as a guide to the strength at which it should be used.

No test for water soluble arsenic was made with any sample, but of the three kinds used by me, none caused any injury to foliage.

It was not intended to test or analyze all the brands of arsenate

* The material may now be obtained from the National Spice Company, 123 Maiden Lane, New York, at a price of 10½c. per pound, in 100-pound steel buckets; cans of one pound, 15c. These prices will probably stand reduction later.

of lead now on the market; simply to call attention to the variation in the amount of arsenic and price, and to give a basis of comparison with Paris green, which farmers have learnt to use. The increasing price of Paris green and the decreasing price of the arsenate of lead may bring them nearer to an equality in economy of application, and then the arsenate of lead will be the most desirable material.

Paris Green.

The sale of this material is now regulated by law in New Jersey and a large number of samples were analyzed by the chemist of the Experiment Station. The results of the work done were published in Bulletin No. 195, and need only to be referred to here. The important point to be noted is that almost all the samples, and all the samples of reputable manufacturers, come up to the required standard and contain no excess of water soluble arsenic. Wherever it can be used without danger to plant foliage this is still the most uniform, and, on the whole, the cheapest of the arsenical insecticides on the market.

Failures to obtain satisfactory results from its use are usually due to some neglect on the part of the users, but there is a small percentage of cases where the material has not been effective and where no apparent fault can be imputed to the operator. It seems as if some unrecognized condition might exist, climatic or otherwise, which in some way influences the resisting powers of the insects.

Antidin.

This is a powdery material of unknown composition received from Europe with the statement that it was used there with satisfactory results on *Phylloxera*. It was also claimed that it could be used against scale insects and that trees badly infested by the San José scale had been completely freed.

Unfortunately only a small sample was sent in, though more was promised, and it was impossible to carry out the plans made for its thorough trial. A material that kills the grape *Phylloxera* might be expected to act equally well on root-maggots, and it was with these that the chief work was to be done, but lack of material prevented.

The sample received was mixed with water, as directed, and remained suspended in flocculent particles, which sank slowly to the bottom. It was painted on the branches of an infested plum tree in an orchard and some of the foliage was wet with it to determine its action upon leaves. Two weeks later examination was made by Mr. Dickerson and neither foliage nor scales had been in the least affected.

A large supply of antidin has been ordered and experiments will be continued in 1907, on subterranean species at least.

Killarvae.

This is a material primarily intended for the destruction of mosquitoes and their larvæ, but from its composition it seemed as if it might possibly have a wider range. It consists of two powders, which if combined in water produce ammonia in sufficient quantity to be unpleasantly apparent. A reference to the section of this report dealing with mosquito matters will show that under some conditions the material was decidedly effective, and it was believed that it might be similarly useful as against root-maggots, while the ammonia produced might be of direct use to the plants. Unfortunately the manufacturer delayed sending in the supply ordered until the maggots had almost disappeared, and it was impossible to make any satisfactory tests. A large supply is now actually in hand, however, and will be used next season, if no unforeseen contingencies prevent.

To test the material on foliage, sprayed, on May 24th, some branches of maple trees near the laboratory. When the mixture was made a strong odor of ammonia was apparent, and the first lot was sprayed out without stirring. It developed in the process that the powders sank to the bottom quite rapidly, so that toward the end the spray was quite a thick mass. The second mixture was kept stirred while the spraying was done.

May 29th, the foliage sprayed with the first lot was somewhat burned where the material was thick, but had not been harmed where the beginning was made. The spraying done with the second lot, which was kept stirred, had hurt nothing; evidently it was the settlings that had caused the mischief.

August 4th, Mr. Dickerson made up a package of the material

and sprayed it on a badly-infested plum tree. Used so little water at first that the nozzle clogged, then allowed it to settle a little and poured off the liquid, which was then sprayed. On the 18th the foliage was slightly burned; the powdery coating on the bark showed obviously where the mixture had been applied, and while there were some crawling larvæ and recent sets some scales appeared to have been killed. On the 25th injury to foliage had intensified, while larvæ and recent sets were as abundant as ever.

September 29th made up another lot of the mixture and sprayed a small, badly-infested peach tree, which had plenty of crawling larvæ and recent sets. The tree had had a coating of carbolic acid on the trunk earlier in the season and showed a powdery, white appearance after the application had been made. Next day the powdery appearance was quite as well marked, but there were as many crawling larvæ as before and there was no evidence that any benefit had been derived.

Miscellaneous.

White hellebore and *ground tobacco* were tested as to their effect upon root-maggots on cabbage and onions, but the details of the experiments come rather with the account of these insects. The materials to be used were purchased by the Station and sent directly to the growers who had agreed to use them in accordance with directions. Mr. Dickerson, under instructions, visited each of them, and explained carefully what was desired, besides leaving a typewritten sheet on which everything was also set out in detail.

Lime and Sulphur Washes.

These combinations Mr. Dickerson has found in very general use, especially in peach orchards. The wash has been made in various ways and the ingredients were used in varying proportions. Within certain limits this variation does not seem to impair effectiveness, and where carefully made and applied the results have been satisfactory on peach, and to perhaps a slightly less extent on plum and young apple trees. Where it has been applied to old apple and pear trees on which the bark has become rough and scaly, the results, on the whole, have not been satisfactory, except where very thorough applications have been made with great force,

or where two sprayings have been made. The unsatisfactory results are due apparently to the fact that the insects are protected to a greater or less extent by the rough bark, or by plant hairs, or that the trees are large, and it is hard to reach all parts and cover thoroughly. In other words, the trouble is mechanical, and is due largely to the character of the wash, which tends to form a coating over a crevice or velvety surface rather than to penetrate into or through it. Brought into direct contact with it, the wash kills scales as readily on apple as on peach. On some pear trees the waxy surface forms an additional obstacle, because the wash will not stick in an even coating, but will run off in streaks.

While some of the sprayers used equal proportions of lime and sulphur, many preferred an excess of lime, and the tendency was to reduce the amount of salt or omit it altogether. Those who used the mixture without salt claim very satisfactory results. In the Hunterdon county districts, near New Germantown and Lebanon, the 40 lime, 30 sulphur and 20 salt to 90-100 gallons of water, is in favor, and some of the farmers boil for their neighbors, while some buy the mixture from dealers in spraying machinery, etc., who make up any desired quantity on order. This is convenient where no great amount of material is needed and the bother and expense of fitting up a boiling plant is a bar to a use of the material.

In making the combination, some, especially those who have had little experience, depend upon the length of time recommended for boiling to obtain a good mixture, but as a rule those who have had experience depend rather upon the appearance of the mixture, and when it has obtained the right color and consistency consider it ready for use, irrespective of the elapsed time.

Only one or two cases of using *self-boiled mixture* are recorded. One of these is a grower near Riverton, who has been successful with such a combination, not only on peach, but also on old, bearing pear and apple trees which in the past were very scaly and are now clean. The success in this instance is due to first-class materials and first-class work. A sufficient excess of lime is used to obtain the heat necessary to make the combination, hot water is used in slaking, and as soon as the materials are mixed and the lime is boiling, the barrel is covered to retain the heat. The application is not only made with great force, but in such excess that a complete coating is formed and every crack or crevice is filled.

Fig 29.

Stock room of Scalecide Laboratory in which the vegetable oils are also stored. From a photograph.

Fig. 28.

Mixing and filling rooms in Scalcende Laboratory, showing three of the five mixing tanks—capacity of each one carload. From a photograph.

Fig. 27.

Scalecide Laboratory at Huckensack, N. J. From a photograph

Lime, sulphur and *caustic soda* has also been used successfully, but probably to a limited extent only. Near Madison, Morris county, large bearing apple trees were seen which were treated with this combination in 1904, and from which the scales had almost completely disappeared. Some plum trees treated in the same way showed almost equally good results. Here also good materials and thorough application counted heavily toward the result.

Those who have used the lime and sulphur mixtures longest and with greatest benefit now understand their limitations fairly well, and do not expect to obtain impossibilities. They realize that the right mixture must be obtained, and that it must strike the scale to kill. They realize also that the mixture goes only where it is put, and that it has no spreading or creeping power.

I advise this mixture for use on peach trees in preference to any other because of the benefit derived by the trees, irrespective of the removal of the scale. Peach trees seem to be more easily covered than any other variety of fruit, and the measure of success is proportionately very great. With a full understanding of the limitations above noted, the peach grower really needs nothing more effective.

As to the proportion of materials to be used, I still prefer for the boiled mixture equal quantities of lime and sulphur, provided the lime is good. If it is of poor grade, more is necessary to get the quantity of actual lime that is needed. The consensus of opinion, based on results throughout the country, seems to be that the salt is neither essential to secure an insecticide effect nor of benefit in forming the combination of lime and sulphur

SCALECIDE.

"Scalecide" is now made at Hackensack, New Jersey, in a brick building, close to the line of the Susquehanna and Western railroad, a siding from which runs the oil cars to a point whence it is drawn directly from them to an underground tank outside the factory. Connected with the main buildings are storage and shipping sheds of ample capacity for the prompt and economical handling of the crude and manufactured products.

Concerning this outfit, which was visited by Mr. Dickerson and

myself early in November, Mr. B. G. Pratt writes: "The factory has been arranged with every labor-saving device, with a view to the most economical production of 'Scalecide.' All raw material is handled by pumps or gravity, giving the chemist in charge the personal control of all raw material without depending on unskilled labor, thus insuring uniformity and exactness throughout the whole operation, and nothing is left to guesswork."

We found the work in progress when we arrived and oil was being pumped from the underground tank into one of the large mixing tanks, of which there are five on the lower floor. Each of these tanks has a capacity of thirty thousand pounds, or a carload of the finished product, and the materials enter from the first story through openings in the floor, from which, also, the process of mixing can be observed by means of electric drop lights. As soon as the gauge shows a proper amount of mineral oil in the tank, one of the vegetable oils is added from barrels—four barrels of the prepared oil which is stored on this first story being run in while the agitators are started to form a homogeneous mixture. On the second story is a large metal tank containing another prepared vegetable oil treated to assist in combining with the mineral oil, and from this a definite quantity, registered by gauge, is next run in. The agitators, when once started, continue their work unceasingly, and from time to time samples are drawn and tested in the laboratory, which is on the floor from which all materials enter the mixing tanks. When the samples drawn indicate a uniform mixture, the alkali and water is added in the correct proportion, and testing begins again until the proper reaction is obtained by the most delicate tests. When this reaction is satisfactory the mixture is complete as to materials and it dissolves or mixes readily with water. It is then tested for stability and agitation is continued until no "cream" separates from the diluted material. Mr. Pratt writes further:

"As each tank is started a consecutive number is given and a complete record made of same. Samples are drawn, labeled and tested, and preserved for future reference. The tank is allowed to stand for at least twenty-four hours after finishing, and then other samples are drawn and tested before receiving the O. K. of the chemist, after which contents are drawn out into barrels and cans, each numbered with the corresponding number of the tank and sample, a record of which is again made on each shipping

order, by which reference to the sample and date of manufacture can be made of any individual shipment at any time by simply giving this number. The greatest care is exercised throughout the whole operation, and finally each barrel is inspected before shipment is made."

It may be added that while the product is drawn from the tanks the agitators are working constantly, so that there is no possibility of a separation or of a difference between barrels of the same lot. The final test from barrels is simply drawing a small sample through the bung hole and dropping into a glass of water. If it dissolves readily and completely into a milky-white emulsion it is passed; if there is any delay in the mixing, or any unusual appearance is noted, the sample is referred to the chemist. The capacity of the plant is three carloads per day.

Concerning the material that goes into the making, Mr. Pratt gives information as follows: "'Scalecide' is not an 'accident,' but the outgrowth of many years of study and experiment on the solubility of oils. In the course of these experiments every known commercial oil has been treated and rendered soluble, both alone and in combination, so that when, in the fall of 1904, Professor Smith suggested the need of a petroleum that was readily and perfectly miscible in water, it was simply a matter of ascertaining the cheapest and best combination that would do the work. Samples of commercial and specially prepared petroleum were obtained from different sources, and finally a partially refined goods was decided on, the light inflammable and the heavy oils being removed, at the same time retaining all the sulphur solutions that are present in most crude oils.

"The next step was to ascertain what other oil or oils in combination, when properly treated, would combine with the largest proportion of this petroleum oil, opening up the globule and allowing the free action of an alkali.

"It might be of interest to those who do not understand the chemistry of fats and oils to say that the only difference between petroleum oil and the animal and vegetable oils that can be saponified or turned into soap is simply one atom of oxygen. If this one atom could be added to all the hydro-carbon combinations in petroleum, a cheap petroleum soap would be possible. As it is, petroleum oil is not acted upon either by the strongest acid or alkali.

"By combining these oils in the proportion of 75 parts of petroleum, 25 parts of combined vegetable oils, to which is added 8 to 10 parts of water and chemicals, the result is a neutral product, which is the nearest approach to a pure petroleum soap that has ever been made. This, on account of its liquid oily appearance, is called soluble petroleum."

As to the cost of the material, the vegetable oils and chemicals used, although forming only 20 per cent. to 25 per cent. of the whole combination, cost four or five times as much as the 70 per cent. petroleum which it contains.

The petroleum which is used is of a brown color, not unlike the usual appearance of ordinary crude, but it lacks the light gasolines or naphthas, and is practically free from vaseline. In its raw state it is therefore not nearly so diffuse as undiluted crude, and, on the other hand, it leaves no penetrating greasy residue of vaseline or paraffine to work into the plant cells. The vegetable oils dry out before they soak in, but they have a tendency to bring the scales into close contact with the bark, and the scurf may remain for an entire season, sometimes giving the trees the appearance of being badly infested when not a living example can be found. At other times the bark may clean up completely, leaving little or no scurf remaining. As the material is completely soluble, all traces of actual combined oil will be washed from the trees. It is almost impossible to injure a dormant tree with "Scalecide," diluted in any reasonable way, and successive applications do not produce a cumulative effect, because no residue remains to accumulate.

A few points developed in reply to questions. Mr. Pratt admits the possibility of a separation of the oils in combination under conditions not well understood, but contends that the separation is more apparent than real, and that a little shaking up will restore the union. It is to discount this unlikely separation that the direction is placed on the outside of each package—"Shake well before using."

The water in combination is necessary to the emulsion, and the loss of any considerable part of this water will impair its solubility. Long standing in dry barrels may cause a loss of water, and hence it will be better to test old material by placing a few drops in water before beginning to use. If it dissolves readily it is all right; if there is any difficulty, add two cups of water to a barrel of "Scalecide" and stir thoroughly. This should restore the

combination, but if not, add more water to the extent of a gallon, and there may even be an excess. An excess is indicated when the material changes to an opaque, creamy tint instead of remaining a clear brown liquid, but the excess will not affect the material so as to prevent use or lessen effect. An important recommendation is that the "Scalecide" should be poured into the water instead of water into "Scalecide." If the oil is put in first and water is added, there will be adhesion to the sides of the vessel and the formation of masses which disintegrate slowly. If the oil is poured into the water it mixes readily. It does not matter how cold the water is, although it does not dissolve as readily at thirty-two degrees to thirty-five degrees as at fifty degrees to sixty degrees, but hot water should not be used. Cold does not affect the combination, but heat may do so by causing the loss of water in the emulsion, hence do not store where the temperature gets above seventy degrees if it can be avoided. Mr. Pratt assures me that their offer to replace unsatisfactory material is made in good faith, but they cannot, of course, undertake to guarantee effect where so much depends upon the user. They assume liability only for defects in the material due to their neglect or failure, and it is to bring out possible defects in their methods that they retain samples from each lot sent out.

After going through the factory and watching the process of making up a carload, and examining the methods of checking, filling and shipping, it seems almost impossible that there should be any material difference in the product sent out, or in the percentage of actual petroleum oil in the different lots. Differences in results must be due to factors outside of the composition of the material itself; but for his own protection and to make certain of the best conditions as to material, every purchaser is advised to use the following precautions:

On receiving a lot of "Scalecide," make a note of the number of the emulsion or lot on each barrel or can. Always shake or mix up well before opening. Test by taking up a spoonful and allowing it to drop slowly into a glass of water; if it dissolves readily and completely and forms a milky emulsion, it is in condition for use. If there is trouble in dissolving, notify the maker if it is a fresh lot; add a little water if it is old. Always put the water, or at least a large part of it, into the spray tank first and pour the "Scalecide" into the water slowly. The resulting emul-

sion should be an absolutely even milky-white liquid, without scum or sediment, and it should remain of the same texture throughout the work. In test tubes the emulsion should remain perfect and without separation, either to bottom or top, for several days.

Used with these precautions any differences in the results obtained cannot be charged to differences in the material, and if a good effect is noted from one application the reason for the failure of another must be sought outside of the composition of the insecticide.

Examinations Made.

In the course of his inspections, Mr. Dickerson examined orchards treated with "Scalecide" in the Hunterdon county peach districts, at many points in Burlington county, at several points in Morris county, in large sections of Mercer county, a few in Middlesex county and a number in Cumberland, Monmouth and other southern counties. These orchards, containing many thousands of trees, were peach, apple and pear, in the order named, and also a few plum and other of the usual fruit trees. His conclusions, based upon these examinations, are that the results have been, on the whole, good, but very irregular, and he suggests several reasons for this—*first*, too great a confidence in the killing power of the material, leading to a careless application, and the belief that it would work around any branch and through any mass of scales, however thick; *second,* used at the strength of 1 to 20, the mixture contained only a small percentage of oil, and, unless very thoroughly applied, not enough actual oil reached the trees to be effective; *third*, the mixture dries rather rapidly and does not leave any deposit or mark to show where it was applied; as a result, unless the work is very carefully done, some parts of the tree are apt to be missed. That the material will do the work, where thoroughly applied, was shown in numerous instances. As an illustration, a badly-infested plum tree was sprayed to a drip, with the result that in the midsummer following it was yet free from live scale. This was one especial instance in a large orchard where it was intended to give the material a severe test, the rest of the trees receiving a more moderate treatment. It simply meant that where enough of the material reached the tree it did the work required. In all cases it mixed well with water and sprayed nicely, for which reasons and the ease of application it was much liked.

"The result of the work is that some who have failed with it will spray with lime, salt and sulphur the coming season; others who had fair success with it will give it another trial, while those who were successful will continue to use it. In all cases I have urged very thorough work and a stronger mixture, and from all I could learn I believe the tendency to be in this direction the coming season."

In a number of cases two applications, fall of 1905 and spring of 1906, were made, and usually with excellent results. In others "Scalecide" was applied in fall, and lime, salt and sulphur in spring, and in one large orchard, so badly infested in 1905 that the fruit was largely unsalable, the insect was almost completely eradicated. The owner referred to this in a letter dated in November, when he mentioned the scale as a "rare bird" on his place.

On the Experiment Orchard "Scalecide" was used in the fall of 1905, and the trees remained in excellent condition throughout 1906, as appears in another part of the report.

An orchard of large apple trees, very badly infested, located not far from New Brunswick, was sprayed with a 1 to 20 mixture through the Niagara sprayer belonging to the Station, under Mr. Dickerson's supervision, in the fall of 1905, and again early in April, 1906. Examination made November 1st by Mr. Dickerson and myself showed some trees almost entirely clean and others, badly infested the year before, in very fair condition, all the fruit seen being fairly or altogether clean. It was also noticed here that the last year's scale covering still remained plastered on many trees, giving the appearance of a worse infestation than actually existed.

The Dickerson peach orchard near Chester, Morris county, containing between five and six hundred bearing trees, variably infested, were sprayed November 9th to 11th, 1905, with the 1 to 20 mixture, and the trees remained in good condition throughout the season, though by no means free from scale at the end of the season.

Experiments were also made with the mixture as a summer application on apple, peach and plum, with the result that it can be used after midsummer with good effect and a fair degree of safety, but on the whole such applications are not advised except on trees so badly infested that the life of the tree is threatened.

Recommendations.

The net result of all the work done by or through the office and in the orchards under all sorts of conditions by all sorts of men is that confidence in the mixture as a scale-killer is justified. But to obtain reliable results, the 1 to 20 mixture is too weak. It contains only about 3½ per cent. of actual oil, and this will not be sufficient to penetrate a thick layer of scales; 1 to 15 will be much more effective, and even that should be very thoroughly applied. Further, because of the practical difficulty of reaching all parts of large trees at any one application, two sprayings are advised, one in fall and the other in spring. There need be no fear of injury from even the most thorough applications at this strength.

TARGET BRAND.

"Target Brand" scale destroyer is a petroleum combination made by the American Horticultural Distributing Company, at Martinsburg, W. Va. I visited their plant in the late fall of 1905, and by the courtesy of the president of the company, Mr. John W. Stewart, and the then chemist, Dr. P. Karutz, I had an opportunity to examine the outfit for making and to learn the composition of some of the insecticides made by the company. In response to my request, the photographs illustrating this report were sent me and also the matter in quotation marks in this account.

The plant consists of a three-story building fifty by one hundred and fifty feet, in which the actual manufacturing is done, and a one-story building fifty by one hundred, which contains storage rooms for the mineral and vegetable oils, as well as engine and boiler-room. The lower floor of the larger building is devoted largely to the shipping department; the middle floor contains laboratory, salesroom, shipping and finishing departments, while the distilling, mixing and other manufacturing is done on the third floor. A siding from the Cumberland Valley railroad runs directly to the building and facilitates the receipt of supplies and delivery of products.

"This soluble oil is composed of a combination of vegetable and non-penetrating mineral oils, made by a very expensive and careful as well as tedious process of blending and cooking. The fact that

Fig. 30.

The Target Brand Scale Destroyer Building at Martinsburg, W. Va. From a photograph.

Fig. 31.

"Distilling Room" in Target Brand Laboratory. From a photograph.

Fig. 32.

A row of mixing machines in Target Brand Laboratory. From a photograph.

we can only manufacture one carload per day will no doubt look like a small one, in consideration of the amount of power and room we have, but that is all that can be made with the present amount of machinery."

"We are also sending you some photographs of both the interior and exterior of our plant, which we trust will give you some idea of the heavy expense that is necessary to make a good product. Every department has to have careful and trained men in order to insure a uniform product, and in fact it must be uniform or it is nothing. To insure this it takes the careful and ever watchful eye of a good, experienced chemist, well versed in the handling of both vegetable and mineral oils."

"The product which we are now manufacturing is the result of many years of hard work, careful study and endless experiments, added to thousands and thousands of dollars spent to accomplish the same. We have made dozens of different soluble oils and experimented with them, some of which were satisfactory so far as killing the scale went, but left a damaging effect from the oil upon the trees."

"We found that in order to make a product to kill scale it must be done without penetrating, but by suffocation. At first we made it with too much body and closed the pores of the trees, which was as bad if not worse than the penetrating, but after several more years we got a basis which, from all appearances, seems to be right, and is right to the best of our knowledge."

"The present product is by far the most tedious and careful as well as expensive of all the different experimental products which this company has made and applied on the two-hundred-acre experimental orchard which is run in connection with this plant."

At the time of my visit the factory at Martinsburg was not running, but I saw the machinery for mixing the oils and in the laboratory was shown, in an experimental way, the combination of the materials. A very high percentage of mineral oil is claimed for this combination, and experimentally the combination can undoubtedly be made. Any process reducing the amount of the emulsifier will reduce the price of the combination, of which the crude oil is the least expensive material. Yet on this point Mr. Stewart writes, "but owing to the very small margin of profit at the present prices, we do not feel that it would be a paying invest-

ment to increase the same," speaking in that connection of the capacity of their plant.

I have no direct information as to the methods of testing the material sent out or of controlling it, but have seen no reason to doubt the uniformity of the product. The same tendency to a separation found in the other soluble oils is undoubtedly to be provided for here, and all the precautions recommended under "Scalecide" should be observed with this material as well, though the distillate employed as a base is different in composition.

"Target Brand" is sold in New Jersey and has been used in various parts of the State, but somehow neither Mr. Dickerson nor myself had any opportunity of examining trees treated with it, hence I am unable to speak of its merits from personal experience. I see no reason why it should not be quite as effective as any other of the oil preparations, and in speaking of "soluble oils" always mean to include it under that general term.

Kill-O-Scale.

I have no personal knowledge of the conditions of or manner in which the manufacture of this compound is carried on. In composition it approaches Scalecide very closely, but has a considerable admixture of free sulphur. This may, under some conditions, add to the killing power of the material, but not to the extent of doubling its money value.

All that has been said as to the manner of using Scalecide will apply here as well, and there is no reason for believing that it will not be quite as effective. Only a few places were found where Kill-O-Scale was used, its price acting as a bar, and in none of these instances was it used alone or so that its effectiveness could be justly determined.

Scale-Skidoo.

A can of this material was sent in for trial by the Gould Chemical Company, of Arlington, N. J., early in June, with the statement that it had been successfully used by a number of persons against the pernicious scale and other insects. Three addresses were furnished, on request, of those who had used the mixture, but for a variety of reasons they were not followed up, the material offering a chance for a successful summer wash.

A practical difficulty in securing dilution with water led to a correspondence in which it was learnt that it was proper to "add the water to the material instead of the material to the water. Our preparation is an oil emulsion, not a soap; neither is it saponified in any way." * * * "It should be diluted with water when ready to use, as all emulsions will separate after being mixed with water for some time, although I have used it myself after it had been mixed in spray pump for two or three days with good results." It was also learned that there was 95 per cent. of oil in the emulsion, but that there might be a slight variation.

The material had a very decided odor of kerosene when opened, and it was noted that there was a covering of clear oil on the surface, which combined with the sediment on shaking and then made a thick, light reddish-gray emulsion. To test its stability, 22 cc. was poured into a test tube and allowed to stand twenty-four hours. It had then separated into four layers, as follows: First, at bottom, 2½ cc. of a dirty reddish-cream color; second, a film of whitish cream between layers first and third; third, the mass of material of a lighter reddish-gray and creamy in consistency, and fourth, a thin layer of oil. All these combined readily on shaking, but separation began again as soon as quiet was restored.

The 1 to 20 dilution was also tested, and to 12½ cc. of Skidoo, well shaken up, 237½ cc. of water was added, making a total of 250 cc. The material dissolved readily and formed an even milky mixture with a slight scum on the surface. Within an hour there was 2 cc. of clear oil on the surface, and after twenty-four hours 10 cc. of clear oil was on top—nearly all there was in the combination—and the balance was a whitish watery mass. This could not be recombined, and after thorough shaking again the oil rose to the surface.

August 18th, applied the 1 to 20 mixture to a small, very scaly apple tree. August 25th, there was little injury to foliage, except at the tips on two limbs, which the leaves were distinctly burned and brown. There were plenty of larvæ and recent sets.

September 29th, the same combination was applied on a plum and on a peach tree, both pretty well infested by scale. Next day the plum showed no signs of injury; there were plenty of crawling larvæ, and it was doubtful whether more than the larvæ actually crawling at the time of the application were killed. On the peach tree the results were similar

The Camden Mixture.

This is a combination by Mr. E. O. Huber, of Camden, New Jersey, and was sent in for trial April 6th, 1906. It appeared to be a resin and petroleum combination, which was unstable in character and separated on standing. Mr. Huber was advised of this fact and sent a somewhat larger quantity about the middle of May, and this combination appeared to be stable.

The directions were to use it at the rate of 1 to 40 or 50 as a summer mixture, 1 to 25 as a winter mixture, and successful use was claimed in Burlington orchards. It was to be shaken up a little, then put in water gradually, at the same time agitating just enough to dissolve.

The first test was for stability of the diluted mixture, and we found that the combination 1 to 50 would stand for several days without separation, meeting every requirement that could even be reasonably made in a practical use.

The next test was as to injury to foliage, and it was found that at 1 to 50 and 1 to 25 there was no injury to maple leaves, these being about as susceptible as any within our experience.

Owing to the small sample, as well as press of other work, no orchard tests were made until August 4th, when Mr. Dickerson sprayed a scaly plum tree with 1 to 20 and a scaly peach tree with 1 to 40.

Two weeks later the plum tree showed some burning effect; some of the leaves were entirely brown and dry, others were somewhat scorched but on the whole the injury was not serious. As to the scales, many had been undoubtedly destroyed, and that more were not killed was due in part at least to the fact that the foliage prevented the spray from reaching the infested wood. There were quite a number of new sets and active larvæ. As compared with a neighboring tree of the same kind sprayed with Scalecide at the same dilution, this showed a somewhat greater burning and rather more recent infestation. The peach tree was uninjured and so were the scales infesting it.

September 29th, sprayed with the 1 to 20 dilution one small bearing apple rather slightly infested; one medium-sized bearing plum badly infested, with many recent sets and active larvæ; one

medium-sized bearing plum of irregular growth and with some of the branches very badly infested.

September 30th, none of the trees showed injury to foliage. The apple had some fresh sets and some active larvæ, but there had been, undoubtedly, a material reduction. The first of the plum trees showed very few active larvæ, and such recent sets as appeared may have been there before the application. The second of the plum trees showed quite a number of active larvæ and fresh sets.

On the whole this mixture has not had a sufficient trial to make it fair to speak positively. It is made up in very small lots only and varies a little in composition, but at the rate of 1 to 40 or 1 to 50, as advised, it will prove absolutely ineffective, simply because no combination containing so small a percentage of petroleum can do any good.

Mechanical Emulsions.

Very much to my surprise Mr. Dickerson found the mechanical mixture of oil and water in high favor and very effective in all cases. He writes: "The oil and water mechanical mixture has been much more extensively used than the undiluted oil, and, so far as I know, the material was crude oil rather than kerosene, applied with a Kerowater pump. I have seen both peach and apple so sprayed in several localities with excellent results. Quite a number of the peach growers will continue to use the mixtures, and others who did use it, but are now using lime, sulphur and salt, did not change because they had not been successful, but because they feared that injury might come from continued applications and because they believed the lime-sulphur washes to be more beneficial to the trees. The tendency, at least in spraying peach trees, is to reduce the proportion of oil in the combination. At first 25 per cent. was used, but now 15 per cent. to 20 per cent. is generally employed. An orchardist near Lambertville furnishes a good example of what has been done with this material. He started to spray five or six years ago with the 25 per cent. mechanical mixture on both bearing apple and peach trees which were more or less scaly. He felt, however, that he was getting too much oil on his trees and reduced it to 20 per cent. This year he sprayed some young peach trees with 15 per cent. I saw the peach orchard which

was first sprayed five or six years ago and every year since. The trees are seven years old, in fine condition, very free from scale; they had borne well and had, when I saw them, so large a crop that it was necessary to thin to prevent them from breaking.

"A White-House orchardist has had a similar experience and now uses a 15 per cent. mixture of oil and water. But he says that while he uses a smaller percentage he actually gets as much oil on the tree, because he sprays longer and covers more evenly. He says he has never noticed injury, and I examined the peach orchards that had been so sprayed for several years and found the trees in fine, healthy, clean condition.

"In one or two instances careless application, which resulted in getting on too much oil, injured peach trees, but in general those using the mixture judge the strength by the appearance of the spray and have learnt to recognize when they get either too little or too much.

"Several of those using the Kerowater pumps say that they do not always distribute accurately, giving a little too much water on the start, but in general the pumps seem to have worked quite satisfactorily and to have given good results."

The interesting feature in this record is that applications on peach, our most susceptible fruit tree, continued for five or six years, have caused no injury or accumulation of injury, though from 15 to 25 per cent. of actual oil has been used. It is important as bearing on the question of whether repeated applications of the soluble oils can cause injury, and would indicate a reply in the negative, since these, as applied, contain only about 4 per cent. of actual oil.

Crude Oil.

Crude oil, in one form or another, is still considerably employed throughout the State, the "insecticide oil" of the Standard Oil Company being the most usual. It is used by few peach-growers, more by growers of apple and pear, and in some cases growers that have failed to destroy the scale on their large, bearing trees with the lime, salt and sulphur wash, are using crude oil with success. Most of the men that use it now understand its penetrating character, and know that while this makes it a scale-killer of the first order, it also makes it dangerous to their trees when care-

Fig. 33.

Crude Oil Spraying. Above, an orchard of old apple trees, very scaly, cut back to stubs, drenched with undiluted oil, now free from scale and ready to bear clean fruit. Below, apple orchard sprayed with undiluted crude oil in 1905, now loaded with fruit. From original photos.

lessly handled. Personal experience has in many cases impressed this upon men who are still using it.

Wherever the oil hits it kills, and if treated trees have not been cleaned it simply means that they have not been thoroughly sprayed. The undiluted oil also shows wherever it has come into contact with the bark, and where I have found live scale on apple trees sprayed with this material I could see just where the oil had not been applied. This is apt to happen where the grower is afraid of getting too much oil on his trees and does not spray thoroughly enough. Some growers have warmed the material before use and claim that it is more penetrating and spreads and covers better than when cold.

Thus far I have quoted largely from Mr. Dickerson's report, and the "I" in the last paragraph is his. Personally I have seen apple trees of large and medium size, so badly infested with scale that they were beginning to die at tips, cut back and sprayed with undiluted oil, afterward recover and make good useful trees. One case especially, in Burlington county, was brought to my attention. When I saw the orchard in the spring of 1905 I would not have given a dollar for its chance of life. The trees were all topped, some of them cut back to stubs, and all were bright chocolate-brown and greasy. Some were starting out, but I would not have been surprised to learn later that the orchard had been cut out. The owner insisted, however, that the trees would come out all right, and he was correct. The photograph here given illustrates the condition of the trees in the summer of 1906, and there was a crop of clean fruit on them. The rest of the farm was cleaned up by a fall application of Scalecide, followed by lime, salt and sulphur in spring. It is further suggestive that this same man is constantly putting out more trees, with full recognition of the fact that he will have to fight scale on them almost from the start.

Kerosene Limoid.

K.-L. has not been very extensively used in New Jersey, so far as our observations extend, and only two cases have been actually verified. In Salem county a nurseryman combines the treatment of trees with the business of growing them, and charges ten cents per gallon of applied mixture. Four thousand five hundred gal-

lons of K.-L. were used and in every instance the application was liberal, since there was no inducement to economy, and the dealer rightly claimed that unless he was allowed to do the work well he could not guarantee a good result. The formula was five gallons of kerosene, twenty pounds of limoid and twenty-five gallons of water, making an actual proportion of one-sixth, or about 16 per cent. kerosene. The oil and limoid were thoroughly mixed together with a hoe, and then, by a like process, the water was mixed as added, and what appeared to be a good combination was obtained. Whenever the infestation was bad a second application was made. So far as the examinations extended the results were good, even where only a single application was made. In only a few cases they were unsatisfactory on old, bearing apples, but in one instance this may have been due to rain coming immediately after the spraying was done. The effect on the trees was not so uniformly good. Apple and pear were safely sprayed in all instances; plums were sometimes injured and young peaches were in some instances killed.

The results prove that the K.-L. will kill scales where used liberally, and will also kill some trees where enough oil gets on them. It is fair to say, however, that the method of mixing was unsatisfactory and not calculated to secure the best results as against the scale or the greatest measure of safety to the trees.

To make an even mixture and get a real emulsion, stirring with a hoe is not enough. There should be a thorough churning by pumping the material back into the tank until it has all passed through the pump at least once and has been forced through the nozzle back into the mixture again with pressure enough to stir it up violently. The injury caused was probably due to free oil contained in the spray as applied.

In Passaic county an orchard of about one hundred and thirty large apple trees was treated for two years in succession with the combination containing about 20 per cent. of kerosene. At the date of inspection, March 22d, 1906, the trees seemed to be in very fair condition, and very little living scale was observed. Later examinations were not made, owing to press of other work.

Carbolic Acid.

This material is not new as a scale-killer, but was tried and abandoned for various reasons soon after experiments began in New Jersey. Nevertheless, reference to it cropped up again in the "Rural New Yorker" and the "American Agriculturist," two of the agricultural papers most widely circulated in New Jersey. The note in the "Rural New Yorker" was as follows:

"An Annandale writer in the High Bridge "Gazette" says: Several of the peach growers in this section are applying crude carbolic acid to their trees to kill the San José scale. John Shurts, of this township, tried this remedy for the scale last year, and says it is a complete success. The acid is applied with a brush to the trunk of the tree to about three feet from the base, when the sap is running up. It is claimed that the acid gets into the sap and is conveyed to all parts of the tree, killing every scale on it. The growers claim that the fruit is not affected by the acid, while the trees are much invigorated. Jeremiah Hall, of Stanton, was the first to discover the value of the acid as a scalecide. The advantage of this treatment over the old is that it will kill the scale after a tree has become affected with it, while nearly all of the old remedies were merely preventives."

The note in the "American Agriculturist" was longer, but covered the same subject:

"A Hunterdon county man, J. H. Hall, has come out with a new remedy for the San José scale. It is crude carbolic acid simply brushed on the trunk of the tree. He and two other fruit growers personally known to the writer have tried it for two seasons, and give strong testimony to its beneficial effects. According to their experience, it means the entire riddance of the tree of this insect pest, but how it does it is not explained. Whether it is the persistent fumes of the stuff constantly arising through the tree-top, or whether it works some slight change in the sap of the tree which makes it unwholesome to the scale, can as yet be only surmised.

"The latter version is usually considered among the impossibilities, but reports of some recent experiments on the current number of the 'Scientific American' do prove that chemicals may enter the sap of a tree and have effect on its health. This, taken in connec-

tion with the fact that insect life is sensitively affected by the food on what it lives, may lead into a new field of investigation.

"The originator of this carbolic treatment says that it is necessary to merely paint a band of the chemical around the trunk. This sounds much like quackery, but the disinterested testimony of those who have tried it and the cheapness and ease of application of the remedy makes it worthy of a trial.

"Farmers in these parts have mostly given up their apple orchards, but there are still quite a number of peach orchards kept in condition by the lime, sulphur and salt treatment. The only peach orchard I have seen, however, that looks like the old-time vigor and health is the orchard of Mr. William Hoffman, near Lebanon, N. J. He has used nothing but lime and sulphur mixed without boiling."

Mr. Dickerson was detailed to look into the matter and he found Mr. Jeremiah Hall, who very kindly drove him to all the places where the carbolic acid had been used, and showed also his own trees where the original experiments were made. The publications above quoted were made early in June, before scale-breeding had started; the examination by Mr. Dickerson was made August 1st, when the second brood was on the move, and when infestation was much better marked where it existed.

Of the trees examined, including the usual orchard fruits, some had received belts a foot wide, and from that varying to the whole trunk and the bases of the branches. Crude carbolic acid, "best quality obtainable," was used, and wherever it covered the insects it has killed them, without apparent harm to the trees in any case. There was no case, however, where any interference with normal breeding was observed outside of the directly treated space, and on most of the trees an abundance of crawling larvæ and living sets was seen. Mr. Hall's own trees were but slightly infested, but there was no evidence that they had ever been worse, and seem to constitute one of those curious exceptions to the general susceptibility that are sometimes discovered. A marked instance of that was noted in Montclair, where a series of infested plum trees became almost entirely free during the past winter, though no treatment whatever was made.

In late fall, while making nursery inspections, Mr. Dickerson ran across an apple orchard of some size in another section of Hun-

terdon county which had been treated to a carbolic acid banding earlier in the season with absolutely no good result.

The only direct experiment was made by Mr. Dickerson on a small bearing peach, very scaly, the trunk of which was painted with the crude carbolic acid August 23d. On September 29th there was no perceptible injury to the bark directly, or to the general health of the tree, while there were plenty of living scales with fresh sets and crawling larvæ all over it. The same tree was made the subject of another experiment on the later date.

It is a very attractive idea to treat the scale in so easy and inexpensive a manner, and some farmers have suffered so much loss that they are ready to grasp at almost anything that promises relief, especially if it is easy to apply and involves no labor in preparation.

Dr. B. D. Halsted, the botanist to the Station, informs me that the outer bark takes no part in feeding a tree, and that there is no circulation through it. The sap is carried through the layer between bark and wood and only the liquids prepared by the root-system are carried through it. It would be impossible for carbolic acid to enter unaltered into the general circulation, and even if all that could soak through the outer bark was carried into the sap as rapidly as it worked through it would be so diluted when it reached the leaves and twigs as to be imperceptible.

Carbolic acid is a good insecticide for some purposes and will kill the pernicious scale when applied to it, but there is no evidence at present that it will kill in any other way.

Whale Oil Soap.

This well-tried material has been used as a winter wash in a very few cases, although frequently recommended and sometimes used as a summer application.

One large peach orchard had been treated with soap for two successive winters, but in 1905-06 a change was made to the lime, salt and sulphur wash. When examined by Mr. Dickerson the trees were in excellent condition and the orchard was very free from scale.

In another locality some large, bearing plums had become so scaly that it was a question whether to take them out or let them

stand. The latter was finally decided upon and they were thoroughly sprayed with whale oil soap. When examined in midsummer the trees were growing well, appeared to be in thrifty condition and very little live scale was apparent.

The excessive cost of the applied mixture is one of the chief objections to it, and the results have not always been so uniformly good as the above record indicates.

Caustic Soda.

Mr. Dickerson's notes are as follows: "Caustic soda, which was used by a number of growers a year or two ago, is not being used by any one at present so far as I know. One year's experience was enough to show the ineffectiveness of the material and the general comment of those who used it is—'Just one year behind in my orchard.'"

TREE TANGLEFOOT.

This is a preparation made by the O. & W. Thum Company, of Grand Rapids, Michigan, who are also the makers of the sticky fly paper sold under the same "Tanglefoot" term. It is of the consistency of soft putty, spreads readily with a trowel or wooden spatula and remains sticky for a long period when exposed to the outer air.

The material is recommended for banding trees where it is desired to prevent insects from traveling up or down the trunks, and a considerable quantity has been used in Massachusetts for banding trees in gypsy moth work.

I had the opportunity of seeing the treated trees during the season of 1905, and it seemed to me that some of the younger, smooth-barked trees had been injured, and I so informed the manufacturers in the course of correspondence. Meanwhile the material had been used in California on a great variety of fruit trees, and seemed to have been of indirect benefit in checking one of the pernicious scale insects.

It appears that one of the parasites of the scale insect is particularly liable to destruction by ants, and as ants occurred abundantly in all orchards and were constantly on the trees in great numbers,

these scale destroyers were themselves destroyed by the ants to such an extent as to render them ineffective as aids to the fruit growers. "Tanglefoot" applied in a continuous band around the trunk formed a barrier which could not be passed by the ants, the scale destroyers were free to develop undisturbed, and this resulted in a marked decrease of pernicious scales with a promise of their total elimination. Reports from growers and inspectors were uniformly to the effect that "Tanglefoot" caused no injury to the banded trees, and correspondence with the Massachusetts users failed to show any case of obvious injury caused by the material.

To put the matter to a direct test in New Jersey, the manufacturers sent me, early in the season, four buckets of "Tanglefoot," which were sent to Horace Roberts, Moorestown, Burlington county; John S. Collins, Moorestown, Burlington county; Henry Pfeiffer, Cologne, Atlantic county, and Joseph H. Black, Son & Company, Hightstown, Mercer county.

To each of these parties a letter was sent explaining the purport of the experiment, and they were asked to make the necessary observations.

Mr. Horace Roberts used the material on apple trees of good size and in bearing condition. When seen by Mr. Dickerson during the summer there was no sign of injury to the trees and no appearance of any beneficial effect as against the scales.

Under date of November 3d, Mr. Roberts wrote that " 'Tanglefoot' still sticks to the trees, but I do not see that it hurts them at all. I am unable to tell whether it helps with the scale or not, for the scale is a very rare bird here now."

Mr. John S. Collins reported, October 26th, that he had used the "Tanglefoot" on peach, pear and apple. There was no appearance of injury at that time, and, on the other hand, no apparent benefit had been derived, so far as lessening scale injury is concerned. The material remained sticky enough to prevent insects from crossing it for some time after it was applied, but at the time of the report it had hardened so that it could be readily crossed by any species.

Mr. Henry Pfeiffer reported, under date of November 1st, that on June 1st he had applied the "Tanglefoot" in a band ten inches wide and one-quarter inch thick to one cherry, one apple, one peach, two pear, one quince, one chestnut, one tulip tree and one

oak. June 2d, he applied it similarly to twenty-four young apple trees two years planted, in alternate rows with check rows between.

June 4th, applied to fifty pear trees, partly infested with scale. Size of trees, one to four inches in diameter, with check rows between.

July 5th, all the trees were examined and the material was found in fairly sticky condition. No apparent harm to any tree, but the treated apples had fewer plant lice than the check rows.

August 1st, the trees still showed no trace of injury, but the banding had hardened sufficiently to make it desirable to retouch with additional material. The treated pear trees showed no difference in scale infestation as compared with the checks, but the treated apple trees looked uniformly better, owing to the smaller amount of plant lice infestation.

October 1st, no injury showed on the treated trees, but the scaly specimens were now so badly infested that active measures were necessary, and they were sprayed very soon afterward with whale oil soap suds, at the rate of one pound in two gallons of water. The "Tanglefoot" was retouched where it had hardened.

November 1st, no treated tree of any kind showed injury or benefit from the application. Mr. Pfeiffer states that he will continue the experiment another year.

During the latter part of the season Mr. Dickerson saw the treated trees of the Joseph H. Black & Son farms at Hightstown, and determined that in some cases material injury had been caused. He requested that the subjects be kept under observation and report made later.

October 5th, the following report was made: "The black walnut that was broken by the wind continued to die down as far as the mixture was applied. The mulberry does not seem to be affected in any way. Sweet cherries do not seem to be affected. Paragon chestnut shows an enlargement where the material was applied on a young tree. An American chestnut that was older does not show much effect as yet. Peach trees show two separate effects; one is to soften the bark and change the color of it and on one tree it is plainly destroying the bark. On a plum tree of a European variety we find that it is having practically the same effect as on the peach, and on a prune tree we find that the bark is made brittle, and yet spongy-looking. A quince seems to have been affected the same as the prune. A Japan walnut does not seem

to be damaged at all. A pear tree has a trifle of the spongy look to the bark, but not so bad as the prune. The large apple tree does not show any effect that would indicate injury. We would never advise its use on fruit trees, especially those belonging to the rose family. Neither would we think it entirely safe on nut trees."

On the whole, judging from observation and experiment, "Tree Tanglefoot" may be considered safe on all the ordinary shade and forest trees when well out of the sapling stage, and that is more especially true of rough or scaly-barked trees. On smooth-barked trees the danger is greater until they are well grown. On apple trees there seems to be little danger when the trees are well grown, and the same is probably true on pear. On young fruit trees I should be afraid of it, no matter what the variety. It is quite possible that some of the younger apple trees treated by Mr. Pfeiffer may show bark injury on closer examination, and, if none is caused now, it may develop in the course of another year if the application is continued.

As to the field for a sticky banding, that is a large one in cities where the tussock moths are to be dealt with, and it may become a very useful material if it becomes necessary to fight the gypsy or brown-tail moths in New Jersey. The results noted by Mr. Pfeiffer on the apple trees will make necessary a closer observation of the plant lice that feed on the tips to determine what natural checks are operative and how these, in turn, are affected.

REPORT OF THE MOSQUITO INVESTIGATIONS IN 1906.

Fig. 1.

An interested audience. One of the attendants on collections in town lot pools. *C. pipiens*, *C. sylvestris*, *C. jamaicensis* and *Anopheles* are found in such pools. From an original photo.

REPORT OF THE MOSQUITO INVESTIGATIONS IN 1906.

BY JOHN B. SMITH.

During the fiscal year, November 1st, 1905, to October 31st, 1906, the sum of $3,500 was available for the purpose of continuing work under chapter 80 of the laws of 1905, and the sum of $6,000 was available for the purpose of aiding communities that might wish to take advantage of the provisions of the law. Of the latter sum, $500 were assigned to the city of Elizabeth and $375 to the borough of Atlantic Highlands; the balance was turned back into the treasury.

The writer has been continued as executive officer under the law, and all investigations have been made under his direction. As field assistant especially for marsh work, Mr. H. H. Brehme has been continued, and as field assistant for inland work and to take charge of the laboratory experiments, Mr. John A. Grossbeck has also been retained.

The fish investigations and experiments referred to in the previous report have been concluded by Mr. W. P. Seal, and his record and conclusions form part of this report. Briefly stated, the experiments have not been as successful as was hoped and expected, and it is decidedly questionable whether the top minnow, *Gambusia affinis,* can be made a permanent inhabitant of any of the natural waters of the State, although this does not mean that it may not have a field in artificial waters not stocked with predatory fish.

Each summer offers climatic peculiarities of its own, and that of 1906 was no exception to the rule. After a normal spring and early summer, during which Newark and Elizabeth secured the full benefit of the marsh work by the absence of the flights that in

the past filled those cities in May and June, came a period of almost daily rains. With these rains came also oppressive, sultry, high temperature, and all those factors that make for rapid and prolific breeding of the common house mosquito, *Culex pipiens*. The result was that during all of midsummer this species increased in numbers where ordinarily few if any came to maturity. It was not all a misfortune, however, since it attracted attention to many breeding places that would otherwise have been overlooked and in several places called attention to the necessity for local work. In the reports on special localities these matters are more particularly referred to, and the report on Mount Holly is typical of conditions that exist in many other places in the State.

A direct result of this accumulation of specimens during the latter part of the season is that there are at present writing great numbers of these house mosquitoes hibernating in the cellars in the localities where they were abundant during the summer. These specimens will furnish the start for the season of 1907, and, if left undisturbed, will provide for an abundant early crop if the weather is at all favorable.

It is quite possible to kill off a very large percentage of this hibernating series—all impregnated females—and every specimen killed off means a potential 200 to 400 new crop. In the report for 1904 it was shown that powdered stramonium or "Jimpson Weed" may be used as a fumigant to kill off the dormant specimens, and on a later page the use of the "Culicide" employed at New Orleans in the campaign against the yellow fever mosquitoes is described. Outfits for fumigating with this material are so very cheap that every local board of health could afford a dozen or more to be loaned to those who wish to treat their cellars. In fact, whoever has an alcohol lamp can make the outfit at a cost of ten to fifteen cents, since an eight-inch section of an ordinary stove pipe furnishes the main part of it.

Attention was also directed to the part played by several sylvan or woods mosquitoes, which also were unusually abundant in some of the hilly parts of the State. These species have only a single brood annually, emerging in late April, but some of them live on until midsummer, and are a nuisance in the woodland and on porches of houses surrounded by trees near their haunts. In the account of the investigations made near Short Hills and Millburn and on the shores of Lake Hopatcong, specific reference is made to

these forms and to the methods of dealing with them. The fact that there is only one brood to be dealt with simplifies matters in one direction, but it also makes it necessary to take measures so early, before adult mosquitoes are ordinarily seen about, that there is great danger of slipping by the proper time.

The Staten Island marsh area, which has been referred to in previous reports, has been eliminated as a danger to New Jersey. The New York Department of Health secured an appropriation sufficient to drain all the marshes on that island, under the direction of Dr. Alvah H. Doty, the health officer of the port of New York, and practically no salt marsh mosquitoes can come from that territory in future. The work has been carefully followed throughout the summer by Mr. Brehme, and a more detailed reference follows.

All the preliminary work necessary to a prompt action under chapter 134 of the laws of 1906 has been done, and there seems to be no reason why a large section of the State near the centre of population should not be cleared during the summer of 1907.

The Jersey City Meadow.

The Jersey City Board of Health has in the past manifested a great interest in the problem of ridding the territory within its jurisdiction of mosquito-breeding places, and during the early months of the year matters looked favorable for securing the funds necessary for the drainage of the salt marshes. April 13th, the meadows were therefore carefully examined and the board was advised of exactly what work was to be done, where a beginning should be made to secure the maximum effect early in the summer, and the amount that would be required to do the work with the percentage that would be available from the State appropriation. The expected funds did not become available, however, and nothing was done to carry out the recommendations made.*

June 28th, the meadow was visited and found to contain a small brood of adults, mostly *cantator,* and the fourth of the season, while in the pools young larvæ of brood 5 were present. The marsh was not again visited until August 22d, just after brood 6, the largest of the season, had made its appearance. This was nearly all

* Since writing the above, $2,500 has been appropriated by the city.

cantator, scarcely 1 per cent. of *sollicitans* being apparent. A high tide had just covered the meadows and left matters in excellent shape for brood 7. Brood 6 migrated north, up the valley of the Hackensack to New Durham, where only a few examples were found, and up the valley of the Passaic to the mountains near Paterson, where they were taken in great abundance. The bulk of the brood remained at Arlington, however, and mosquitoes were very plentiful there on August 21st.

Hot, sultry weather favored brood 7, and it was on the wing August 30th, only from ten to twelve days after brood 6. There were about 70 per cent. *cantator* to 30 per cent. *sollicitans*, and the prevailing southwest wind carried almost the whole output into Jersey City.

Brood 8 was much smaller and was found on the wing September 17th in the proportion of 60 per cent. *cantator* to 40 per cent. *sollicitans*. Its flight was not traced nor was the meadow again inspected prior to November 1st.

Newark.

Newark and its vicinity has been kept under close observation for several reasons. *First*, it is matter of very great importance that the work of the ditches should be watched to note what deterioration, if any, takes place, whether there is any impairment of effectiveness and whether they are sufficient in size and number to meet the requirement of the seasons as they vary from year to year; *second*, encroachments upon the marshes are made each year by the growing city and careless interference with the drainage scheme might easily change a safe area to a mosquito breeder; *third*, the city of Newark maintains an inspector on the marshes throughout the season, and it was desired to make use of his observations on the habits of marsh species; *fourth*, it was desired to determine the location of the local breeding places and to assist the local authorities in their efforts to lessen the pest.

The general results were that the city of Newark was almost totally free from salt marsh mosquitoes during the early part of the summer, and later only a few were found from the Elizabeth or Jersey City marshes. The frequent rains and hot, sultry weather during a portion of the summer was unusually favorable to the

development of the common house mosquito, *Culex pipiens,* and this was present in altogether unusual abundance late in summer.

The whole matter was in the hands of Mr. Brehme, and he reports a total of twenty-nine inspections during the season with the following results:

January 11th, investigated the work in progress at Bound creek to learn whether the dredgers were interfering with the drainage. Found that ditches had been dug outside the embankment limiting the area to be filled and no interference.

April 6th, found a new railroad embankment being run across the Hamburg Place section of the meadow without regard to the drainage scheme, blocking ditches and interrupting the course of a creek, which threatened to turn a safe meadow into a bog hole. The board of health was notified, and they, in turn, served the offending railroad company with notice to restore drainage. This order was eventually complied with, as inspections made April 21st and 26th determined.

April 27th, an investigation was made as to the effect of some dumping operations on one of the drained sections, and it was found that this, too, was being done without regard to the drainage. The contractors were ordered to cease dumping and a new outlet was established into the bay, so that live water was admitted into the ditches. Up to this time the meadow was in good condition everywhere, and no mosquito breeding was going on anywhere.

May 7th, the Bloomfield avenue area was inspected. This in previous years had been a breeding place for a number of the spring species, but was now so densely overgrown that only a few insignificant pools remained, and in these only a few *C. canadensis* larvæ were found.

May 14th, an evening tour was made to determine whether any specimens from the salt marshes were to be found. Only isolated examples could be found, where in previous years, at the same season, they could be swept up by the quart, in stores.

May 16th, the lower section of the city was inspected for the board of health, to determine whether a suspected area was a breeding place for salt marsh species. The area was found to be a fresh-water swamp section, without indication of present mosquito danger.

Night inspections were continued May 16th and 17th, and only isolated examples of *cantator* were seen. People were sitting out everywhere, in comfort, and no one was fighting mosquitoes.

May 26th, the marsh was found dry, free from mosquito-breeding places, and even on the Ebeling tract Mr. Erhard had little trouble in killing off the small brood that hatched there. Then came a two-days rain, measuring 3.16 inches, and the marsh was again examined May 29th. Everything was covered with water, but the ditches were working properly, and on the 31st all the water was gone except in a few places, where so little remained that its disappearance was a matter of hours only.

There was a very high tide June 12th, and on the 13th it was found that the Hamburg Place area had been covered, bringing up "killies" everywhere; the ditches were working properly and Mr. Erhard was removing such driftage as was likely to obstruct the free outflow of water. All the other areas were already drained clear and no pools remained.

June 18th, a city inspection was made over areas where *pipiens* had been known to breed and it was found that the local board had done good work, oiling some places and filling others with earth or ashes, so as to dispose of them finally.

A period of high tides being in progress, the meadow was visited June 19th, and found to be water-soaked, with all depressings full of water, only a few of them with "killies." June 24th, the meadow was again dry except on the Ebeling tract, on which there was quite some water containing scattering larvæ. A few of these developed into adults before the water was all off, but none developed elsewhere on the meadow.

June 27th, the Bloomfield area was again visited and eighteen larvæ were found after the closest kind of collecting. These were *C. territans,* 12; *C. sylvestris,* 3; *Psorophora ciliata,* 1; *Anopheles sp.,* 2. An inspection of Branch Brook Park was made during the same day and larvæ were found in some of the catch basins. The secretary of the commission was notified and thereafter these places were regularly oiled and no breeding was permitted.

July 3d, the fourth marsh brood was on the undrained meadows and the Newark areas were visited to see to what extent it was represented. Only on the Ebeling tract was any breeding going on, and even that was so scattering that little could be determined.

It was estimated that 75 per cent. of the insects were *cantator* and 25 per cent. were *sollicitans*. A month later no breeding was found anywhere on the meadow.

August 12th, an inspection was made in the southwestern part of the city to locate breeding places of *C. pipiens*, and several cellars of houses in course of erection were found filled with water and swarming with larvæ and pupæ. This had been cured on the 24th, and the filling of pools and similar places was continued.

August 25th, no breeding was found in any of the public parks and in Branch Brook only a few *cantator* were discovered, obviously migrants from the Jersey City meadows on a northeast wind of several days' duration.

August 29th, the marshes were dry and safe, except on the Ebeling tract, where a few larvæ were found, and even there nothing was found September 18th. On the 19th a tour of the city showed that the board of health inspectors were still running down and eliminating local breeding places and that conditions were everywhere better than ever before.

September 22d, the first high tide of the fall came in and the meadows, which were dry in the morning, were completely flooded soon after noon, but with the flood came the "killies" in shoals to take care of any larvæ that might hatch.

October 1st, it was found that another railroad spur was being built without regard to drainage; the matter was reported by Mr. Erhard, and the company, in response to orders from the board, built a culvert that preserved the drainage. On the 6th the meadow was in good condition, but it was found that near the boat-houses along the bay shore barrels and boats containing water were swarming with larvæ of *C. pipiens*.

The marsh drainage work has stood the test of a very severe season perfectly, and Newark was freer of marsh mosquitoes than ever before.

Some sections of the city remained practically free from mosquitoes until late in the season, while others were severely infested, but in those cases it was the local breeder *pipiens* that was in fault, and the board of health did excellent work in locating and abolishing places that in ordinary seasons would not be dangerous, and are now finally done away with. It was also practically demonstrated that boards of health have ample power to enforce their

orders concerning the preservation of drainage even against railroads. After a few prosecutions for interfering with ditches, haymakers on the meadows have found it advisable to bridge them wherever it is necessary to drive across.

Elizabeth.

Fewer mosquitoes hatched from the Elizabeth meadows than in any previous years, and that is largely due to the drainage work done under the direction of the board of health of that city during the two or three years last past. Elizabeth took advantage of the State law and secured in 1905 $500 of State aid by an appropriation of $2,000, and in 1906 nearly the same amount by an appropriation of $1,500. In addition, the Central Railroad of New Jersey contributed the sum of $1,000 in return for certain desired concessions, so that altogether about $5,500 have been expended. Previously, and indeed this was the first marsh work in the State, ditching had been done along the Elizabeth river, so that a great deal of the worst mosquito-breeding territory has been completely eliminated. At the present writing a large section of the marsh area east of the Newark branch of the Central railroad, nearest to Elizabethport, is completely drained. Great ditch has been cleaned and deepened where needed; a wide, deep ditch has cut off angles, and a connection with a branch of Woodruff creek has established a tidewater circulation which replaces the former stagnant condition. Two tide-gates, now in process of building, will prevent future overflow of the southwestern part of the meadow, and will lower the water level materially during the ensuing winter.

Mr. Brehme's reports show that he made twenty-three visits to the meadows during the season, and he states that brood after brood was killed off on the drained area, materially lessening the output of the meadow as a whole. The surface was covered with eggs, and whenever tide or heavy rains filled the depressions, larvæ appeared, lived for a day or two, and then by the millions their bodies covered the surface of the dried-off soil.

The first trip was made April 19th, with Mr. Louis J. Richards, the health inspector of the city, to determine the amount of work that still remained to be done on the Elizabeth river section.

Larvæ of the first brood were then observed, but no especial notes were made as to kinds or proportions.

May 10th and 11th were spent in laying out the ditch system with Mr. Richards, and a very large number of larvæ and pupæ, forming brood 2, was observed. This brood hatched about May 15th, and was followed along the Elizabeth river, through Elizabeth, Aldene, Salem, Union, Springfield and Maplewood, which it reached May 21st. The brood may have reached Summit and extended even further inland, but was not followed beyond the First mountains. It was *cantator* almost entirely.

June 1st, after a period of low tides, many pools were dry on even the undrained meadow, and a large portion of brood No. 3, which was then in the first larval stage, was killed off. The entire night was passed on the meadow with Mr. Erhard, and 278 mosquitoes—130 *cantator,* 148 *sollicitans*—were captured biting. The object was to determine the question of the hours at which the insects were most active, and the following table shows that clearly. All the specimens were those attacking Mr. Brehme only, and the fact that there were so few shows in itself how much better conditions were than in past years, when counting would have been impossible. The night, it should be said, was warm and without wind:

Between the hours—	*Cantator.*	*Sollicitans.*
5–6 P. M.	16	9
6–7 "	23	19
7–8 "	30	27
8–9 "	13	14
9–10 "	5	7
10–11 "	1	1
11–12 "	2	..
12–1 A. M.	1	..
1–2 "	2	..
2–3 "	..	2
3–4 "	1	3
4–5 "	14	20
5–6 "	22	46
	130	148

It appears, therefore, that as between the two, *sollicitans* seems to have a period of rest during the middle of the night, but is much more active than *cantator* in the morning hours. And the propor-

tion is greater than shown by the figures, because the actual number of *cantator* on the meadow was as about 8 to 2 of *sollicitans*.

The advance guard of brood 3 emerged June 10th and 11th and left the meadow almost immediately. A few were seen in southwestern Newark on the 13th and some of them got as far as Irvington, which seems to have been their migration limit. A high tide on the 12th flooded the meadows and brought up "killies" enough to wipe out fully half of the full-grown larvæ and pupæ that remained in the pools. What remained was on the wing on the 20th, and this section reached Short Hills and the South Mountain Reservation June 25th, when nine *cantator* and five *sollicitans* were taken there. Newly-hatched larvæ of the fourth brood were found June 24th, on the 29th they were nearly fully developed and a few pupæ had formed, and on July 3d the adults were on the wing. They moved inland slowly and reached Short Hills about July 12th. Twenty-one specimens were captured there on the 14th. *Cantator* and *sollicitans* were almost equally represented in this brood. Brood 5 was another small one and was found on the meadow, becoming adult between July 25th and 28th. It was about 80 per cent. *cantator* to 20 per cent. *sollicitans*, and did not get inland further than Irvington.

August 10th, the meadow was in normal condition, the drained area with only a few odd pools containing larvæ, the rest with larvæ of brood 6 full grown and pupating. August 13th this brood hatched, 85 per cent. *sollicitans* to 15 per cent. *cantator*, and left the meadow almost immediately. Before the meadow was reached from North Elizabeth hundreds of *sollicitans* were encountered, while on the meadow itself comparatively small numbers only remained. This was a large brood and easily followed through every town well into Summit, where a goodly number was taken July 18th. This brood traveled almost directly west, and the towns north of Irvington, Maplewood and Millburn got only single specimens, while Irvington, Springfield, Millburn, Short Hills and Summit got a full supply. The city of Elizabeth got its first notable supply from brood 6, and fully 90 per cent. of this brood left the meadow, which, for a time, was much freer from mosquitoes than the neighboring highland.

August 23d, the work of relieving Great ditch was well advanced, and 1,650 feet of ditch six feet wide and five feet deep has

been completed by Mr. Richards. There was plenty of water on the undrained meadow and young larvæ of brood 7 were in evidence. Five days later it was seen that cleaning and relieving Great ditch had helped the meadow greatly and had taken off many tons of water. Brood 7 was nearing the pupal stage and promised to be much smaller than 6. It matured August 31st, was 65 per cent. *sollicitans* to 35 per cent. *cantator,* and did not seem inclined to migrate. Fully 90 per cent. remained in the meadow and the balance did not get further west than North Elizabeth.

September 8th, the work of clearing Great ditch and cutting the new ditch to connect with Woodruff creek was making good headway and another brood of larvæ was found in the pools, the eighth of the season. The meadow was in a normal condition, *i. e.,* on the undrained portion about 75 per cent. of the depressions contained water and about half of these were filled with wrigglers, the balance containing "killies." A week later brood 8 was nearly mature, but had been much reduced by the drying out of pools. September 18th it was on the wing, 70 per cent. *sollicitans* to 30 per cent. *cantator.* Most of these remained on the marshes and few got further inland than North Elizabeth.

September 27th, brood 9 was found to be well advanced, and on October 2d it was on the wing, a very small one, because the high tide of September 22d had brought in "killies" enough to clean out every infested pool that was reached. Ninety per cent. of these insects were *sollicitans,* 9 per cent. were *cantator* and 1 per cent. was *salinarius,* the first appearance of this species for the season in appreciable numbers. This was another stay-at-home brood, and did not extend beyond North Elizabeth.

October 12th, a series of low tides had left the meadow very dry, and in the remaining pools young larvæ of brood 10 were found. This brood was almost completely destroyed by the high tides, which brought fish to almost every pool on the meadow. It was the last brood that could be enumerated, because later only isolated pools with wrigglers were found.

October 19th, the last regular inspection was made, the work of cleaning Great ditch, the railroad ditch, and cutting the connecting ditch to Woodruff creek was nearly completed, and actual completion was awaiting money enough to do the work. On the whole, what was done is completed in the best possible manner,

and things are in excellent shape for a completion of the drainage scheme under the new law.

Several city inspections were made to find local breeding places, and quite a number of these were found and reported to Mr. Richards, who took prompt action upon them.

The Linden Marshes.

The territory between the Elizabeth City line and the Rahway river, and south of it to Carteret, have been roughly called the Linden meadows, because most of the area lies within the township of that name. It is one of the most virulent breeding places in the district north of Sandy Hook, and from it the migrations extend up the valleys of the Elizabeth and Rahway rivers, but principally up the latter, to the second range of the Orange mountains. It supplements the crop of the Elizabeth meadows and the swarms spread out along the tributaries of the Rahway to Plainfield, Scotch Plains and that general territory. There is no other area as important in its effects on the settlements near the gap in the mountains through which the Rahway river flows, and for that reason several inspections were made during the summer, and a drainage scheme was worked out, to be carried out during the season of 1907, if possible.

The first inspection, made June 6th, when brood No. 3 was in the pools and some eight hundred larvæ were taken to determine the species. All proved to be *sollicitans,* and, because a great many of the breeding pools had a stock of "killies," the brood was not a very large one.

July 6th, brood No. 4 was on the wing, and this, consisting of 80 per cent. *sollicitans* to 20 per cent. *cantator,* was traced to Short Hills.

Beginning July 12th, the actual survey of the meadow and preparation of the drainage plan was commenced, and continued, with interruptions, to July 24th, when it was completed to Port Reading. The whole marsh area was surveyed and plotted out irrespective of township lines, though in such manner as to make it possible to estimate on each section by itself.

During the last days of August brood No. 7 came to maturity, and on September 5th adults were on the meadow in countless

Fig. 2.

Atlantic Highlands. Two views of the Bulkhead at the mouth of Manymind Creek to prevent silting up. From an original photo.

Fig. 3.

Atlantic Highlands. Above is a ditch with gravelly sides from which a sod had broken so as to block drainage. Below is Manymind Creek which takes the drainage of this marsh area. From an original photo.

numbers, almost exclusively *sollicitans*, *C. cantator* being represented by straggling specimens only. This was the largest brood of the season and almost all its members remained on the meadow. There was a little invasion of the adjacent high land, but no real migration.

Atlantic Highlands.

The borough of Atlantic Highlands has within its limits a narrow, winding stream—Many-mind creek—which empties into Raritan bay, and which has been subject to changes in course at its mouth through winter storms and by the action of the waves. On both sides of this stream is an area of low marsh land, frequently covered by the tides, and which was an ideal breeding place for mosquitoes. Whenever the waves had filled or obstructed the mouth of the creek this area would fill up and remain filled until a heavy rain or the accumulation from above would be sufficient to enable the stream to force its way through the obstruction and open up its mouth to the bay.

A drainage commission appointed under the law had expended a considerable sum in improving conditions, had deepened and cleaned out the creek, and had begun the construction of a bulkhead to protect the mouth of the creek. Application was made for assistance from the State fund, and about the middle of June a preliminary survey was made. There was some question as to just what method of improvement was best adapted to the local conditions, but after some conferences it was decided that ditching would hold if properly placed, and the contract for drainage was awarded, the work to be approved by the surveyor for the commission and Mr. Brehme. It was not until late in September that the work was finally begun after the ditches had been staked out by Mr. Brehme, but they were completed and certified in satisfactory condition on October 13th. A bulkhead extending out some two hundred and fifty feet through the surf has also been erected, and will, it is believed, be sufficient to protect the mouth of the creek from further impairment by the sea. On November 5th I went over the ground with Mr. Brehme and the contractor, and the result seems to be satisfactory. In some places the ditches run through a sandy streak, and must be sloped and looked after, but there seems to be no reason why, with reasonable care, the drainage

system should not be maintained and this marsh area kept free from breeding places in the future. The sum of $375 was certified from the fund appropriated under the law of 1905 to assist in the completion of this work.

Shrewsbury River Area.

An account of the work done at Monmouth Beach and other points along the Shrewsbury river has been given in previous reports, and the entire region to Long Branch has been kept under more or less constant observation during the summer by Mr. Brehme. The area at Port-au-Peck had not been included in the work done in previous years, and proved a source of annoyance to the residents of the region that had already been drained. So well convinced were these that the drainage work was a success for the purpose for which it was intended that they raised money by subscription to get rid of the last breeding area within their jurisdiction. This Port-au-Peck marsh had been in the market for some time, but an intending purchaser had incautiously been taken upon it in a mosquito season, and his intentions changed straightway. The character of the drainage required was determined by Mr. Brehme and reported upon, and work was begun early in April, when the first brood of larvæ had just made its appearance. The work was laid out so as to get through the worst breeding sections first, and the main ditches were so placed as to run off the greatest possible amount of surface water in the least possible time. Examinations were made April 17th and 27th, and again on May 2d, when the work was found to be completed, and a certificate to that effect was given the contractor. Not a specimen of this brood was allowed to get on the wing.

June 17th the whole marsh area was found to be in excellent condition and not a marsh mosquito was found, but some *C. pipiens* had been bred in gutters and cesspools, and these were in evidence. July 5th, marsh conditions continued to be good, but town conditions were worse. The surface water due to rains had not been kept down, and *C. pipiens* was becoming more numerous. On August 7th matters had become so much worse that a systematic inspection was made, the breeding pools and gutters were enumerated and located, and a report was made to the Monmouth Beach Protective Association. This report was later referred to the board of health and acted upon.

Fig. 6.

Machine-Cut Ditches, 21 x 30 inches, showing the huge sods taken out by the machine on the Staten Island Marshes. From a photo made for Dr. A. H. Doty.

Fig. 5.

Machine-Cut Ditches, 9 x 30 inches, draining the Staten Island Marshes. From a photo made for Dr. A. H. Doty.

Fig. 4.

A ditching gang at work on the Staten Island Marshes. From a photo made for Dr. A. H. Doty.

August 8th, the Rumson Neck area was looked over and the marsh was found in good condition. On the upland some *C. pipiens* were breeding, but they were not numerous at this time. The Port-au-Peck property had been sold since it was drained and tents were now found on it to shelter camping parties. A year ago it was almost impossible to get on the meadow at all without gum boots, and no camping party would have maintained itself twenty-four hours, if, indeed, it persisted long enough to pitch its tents properly. It was learned that some hundred houses had been planned for at this point, increasing property values many hundred per cent., all because the marsh mosquitoes had been eliminated.

At North Long Branch, which has a small salt marsh area which is not yet drained, some *C. sollicitans* were found August 9th, and there were also some *C. pipiens* that were town bred. At Long Branch proper only the local *C. pipiens* was found.

September 1st and 3d the final inspection of the marsh areas was made and no breeding was found. The drainage scheme works perfectly, and so far as could be discovered not a single marsh mosquito developed, where untold millions emerged in years gone by. The entire area is kept in order by one man with a motor boat who gets from one point to another, patrols the ditches to see that there is no interference and removes any obstructions that may be brought in by tides or the wash from waves caused by steamers or otherwise.

Whatever mosquitoes were found in this region were bred in neglected gutters, lot pools, cesspools and other stagnant water areas. After attention had been called to it matters improved, and on September 1st the clogged gutters were found opened, many pools had been filled or graded and other places had been oiled. It will not do even for communities that have destroyed the marsh species to neglect the conditions that favor the development of *pipiens* in a season like that of 1906.

STATEN ISLAND.

The work done on Staten Island has been kept under constant observation because of its bearing upon the effectiveness of the work to be done in New Jersey. The Arthur Kill, which separates the island from the New Jersey mainland, is so narrow that it

forms no sort of bar to the flight of the salt marsh mosquitoes from one side to the other. Until Staten Island conditions were improved, the New Jersey communities from Newark to Perth Amboy and further inland would be subject to periodical invasions, and, on the other hand, the Staten Island communities cannot get the full benefit of their work until the New Jersey marshes between the same points are cleaned up.

Efforts were therefore made from the beginning to secure the co-operation of the New York authorities, and the New York Department of Health, mainly through the influence of Dr. Alvah H. Doty, has accepted in full the general plan of extermination advocated in New Jersey. Dr. Doty had made a study of the subject as it manifested itself on Staten Island, and had, independently, reached much the same conclusions as the writer. Consequently he was quite ready to accept responsibility for carrying out the plans suggested for Staten Island, and a survey of the marsh area was made at his request, upon which an estimate of probable cost was made which resulted in an appropriation for the work by the City of New York.

The general plan of this work is much like that followed for the Newark and Elizabeth marshes, and it involved the entire island. Work was started in the fall of 1905 and completed on the east and south shore before the opening of the spring of 1906. On the western shore the work has been continued throughout the summer and is now (November) practically completed. The object has been to drain off all surface water so as to prevent mosquito breeding, and that work has been an unqualified success. For the entire season the Midland and South Beach shore resorts have been practically free from mosquitoes and have prospered beyond all measure. Where, in previous years, approaching dusk heralded a homeward movement because the mosquito pest became simply unendurable, during the past season the evenings were the most enjoyable periods of the days. Putting up the screens was postponed from time to time until the summer was gone, and it was realized that there had been a real revolution. Where, in past seasons porches were used only when carefully screened in, these screened-in areas were not used at all. The members of the Country Club and frequenters of the golf links derived the full benefit of the improvement, and while no body of men had been more

sceptical as to results, they are now convinced and even enthusiastic. The direct results of the work have been: improvement in the meadow conditions, so that they now grow good salt hay, which can be harvested safely and easily, where there were only bog morasses with useless grasses before; increase in land values, due to its becoming more desirable for residential purposes; increased prosperity of the shore resorts and the consequent addition of new and much greater amusement enterprises; the utilization of some of the drained areas for industrial establishments employing an aggregate of nearly ten thousand men.

It would be absurd to say that there were no mosquitoes at all on Staten Island during the summer, for the season was a trying one and *pipiens* bred wherever there was a chance for it. But it was a test of the effectiveness of the drainage scheme under the most trying conditions, and it stood the test perfectly; practically no salt marsh species developed on the drained areas.

But Dr. Doty took advantage of the season to locate the breeding places for the inland species, for wherever standing water could exist it existed this year, and an enormous improvement has been made in this direction, the benefit from which will be apparent in 1907.

Altogether, Staten Island may serve as an object lesson, and the work done there has been suggestive in many ways that will be useful in the New Jersey work, besides removing the danger to our citizens to which reference has been previously made.

In the New York "Globe," for November 14th, 1906, is a fair statement of what has been accomplished and of the benefits derived by the community. Dr. Doty informs me that the total area drained is twenty square miles and that about 400 miles of ditches have been actually dug. A large percentage of this ditching was done with the True ditcher, illustrated in earlier reports, and these ditches are nine inches wide and twenty-four inches deep.

Arlington.

Three inspections were made during the season to ascertain whether local breeding places existed and what particular species were troublesome. The first of these, made May 25th, showed

matters in good condition, no breeding places obvious and no mosquitoes flying.

July 10th, a few specimens of the salt marsh species were found, but no locals and no active breeding places. Some of the danger points where breeding had been found in previous years were in process of elimination by filling and grading.

August 21st, both the salt marsh species were present in large numbers, though *cantator* outnumbered *sollicitans* ten to one. This was the flight of brood 6 from the Jersey City meadow, and filled all parts of the town. No breeding places were found in the wooded area, nor indeed elsewhere in the public places in the town limits.

Point-No-Point.

This is the triangular body of land at the junction of the Hackensack and Passaic rivers where they enter Newark bay, and it extends north to the main line of the Pennsylvania railroad. It was, when the mosquito investigation was first begun, one of the worst breeding places in the State and the source of an unlimited supply to the surrounding territory. Its position is such that migrating swarms could reach Jersey City, Newark, Elizabeth and the valleys of both Hackensack and Passaic with equal facility, and no more objectionable spot existed.

Three years ago the Hackensack Meadows Company began covering over this area with sand by means of hydraulic dredges, and Mr. Brehme reports: "While the entire meadow is not yet filled, enough sand is flooded over it to fill the blind ditches and breeding pools. Six thorough inspections were made during the season and not one mosquito larva was found." As a breeding place this area is no longer of importance, and it forms an important link in the chain of work needed to eliminate the mosquito pest from the most densely populated section of the State.

East Orange.

At the request of and in company with Mr. Roger H. Butterworth, president of the local board of health, Mr. Grossbeck in June examined a number of localities suspected as mosquito breeders. Some low open meadow areas with tussocks and long

grass patches looked bad, but turned out nothing worse than a few *C. territans* larvæ. A swampy area around the works of the Orange Water Company, caused by an overflow from disused wells, was found more dangerous, larvæ of *Culex territans* and *pipiens* occurring in some numbers, while associated with *territans* the larvæ of *Anopheles* were also found in such numbers as to indicate that they probably occurred throughout the entire area.

As this was early for *Anopheles*, the indications were that later in the season matters would become much worse, especially if rains provided additional water. The water company had been served with a notice to drain the land, but had paid no attention to it, but the discovery of the actual presence of *Anopheles* larvæ so clearly brought the area under the ban of the health laws that a threat from the board to act at the expense of the water company resulted in the immediate improvement of the danger area.

The worst place found was a ditch almost a mile in length, partly open and in places almost stagnant, into which a large amount of surface water, etc., is drained. East Orange has the separate system of sewers, which receives no surface water, and many cellars and the like are connected with drains that empty into this ditch. While it is not, therefore, really an open sewer, it comes very near to it. Along the stagnant and slow-moving areas half-grown larvæ of *C. pipiens* were dipped up in such numbers that each glassful contained hundreds. Adults were plentiful along the margins, and on the surface an average of at least one egg-boat a foot could be seen. It is obvious that this one ditch alone could produce a fair-sized infestation for the entire municipality, and the governing body was notified, oil being applied as an immediate remedy for existing conditions.

This is one of those cases that needs constant watching. At present it seems impossible to do without the ditch; there is not much fall to the outlet and stagnation cannot be altogether prevented, even with the best looking after. But whenever clogging is permitted by the growth of vegetation or otherwise, a veritable mosquito mill is established which must receive periodical oil applications to keep it in measurably safe condition. No *Anopheles* larvæ were found, and perhaps none are apt to develop there.

Mr. Butterworth informed me that after his notice the city authorities improved matters somewhat, but they could not give

permanent relief by closing the ditch or putting a pipe in its place. It is realized that the place needs watching, and such conditions occur in many places, giving rise to local infestations complained of.

Orange Mountain Towns.

The towns and villages along the range of the Orange or Watchung mountains are fast increasing in size, wealth and population, and are in every respect desirable as places of residence. Unfortunately they suffer at times from the mosquito pest, and South Orange was among the first, if not actually the first, municipality in the State to consider the question and to attempt to secure relief by local work. No other community has done so much really satisfactory work as South Orange has done under the leadership of Mr. Spencer Miller, and few settlements are so free from local breeding places. The experience gained in that work may well serve as an aid to other bodies, and to some extent the example has been followed in the neighborhood. But in the course of the work it developed that local action, important as it was and effective as it proved, could not be alone relied upon. Mosquitoes came in from other places, and the idea that a hundred feet or even yards was the limit of flight of an adult mosquito was definitely exploded.

So much appeared in publications of various kinds on the mosquito subject that a number of other communities along this same ridge have inquired as to what could be done for their relief. This induced me to provide for a series of collections and inspections extending through the South Mountain Reservation, Maplewood, Springfield, Millburn, Short Hills and Summit, to determine just what kind of mosquitoes were offensive and just where they bred.

Mr. Brehme and Mr. Grossbeck were both assigned to the work and separately and together went over the ground from time to time, Mr. Brehme in his task of following the migrations from the salt marshes, Mr. Grossbeck to locate the woodland areas. To determine the species actually troublesome on porches and in gardens, Mr. Wm. W. Renwick, of Millburn, was good enough to send in examples at intervals throughout the season.

The first trip was made April 20th and 21st over the South Mountain Reservation, and larvæ were collected in small numbers

throughout the woodland pools. There was not a great deal of water anywhere at this time and no mosquitoes were on the wing. Of the larvæ sent in all save two or three proved to be *Culex canadensis*. The exceptions were a specimen or two of *C. absserratus* and one of *C. abfitchii-siphonalis*. *C. canadensis* is always the common woods mosquito of early spring, bites freely but not viciously, is easily scared off, rarely ventures outside the woods, never enters houses, but does occasionally get on porches where they are well shaded by trees. Its life is short as a rule, and while there seem to be fractional broods later in the season the mosquitoes are so rarely seen that they are scarcely to be ranked as pestiferous. Until the present year the other species were so rare that we had only a few examples in the collection and both have been recognized as species only within two years.

April 22d and 23d it rained, a soaking spring rain that left much water on the ground, and on the 24th Mr. Brehme made another collection over the same general area, taking 334 larvæ, mostly of recent hatching. Most of these also proved to be *C. canadensis*, but there were a few *absserratus* and *abfitchii*. A collection made on April 28th showed the same characteristics.

May 2d, thirteen adult mosquitoes were sent in from Millburn, and of these twelve were *C. cantator* or salt marsh migrants and one was *C. abfitchii*. On the same day Mr. Grossbeck went through Millburn township with specific instructions to investigate the "keetle" or "pot holes" between the wooded knolls or hillocks. These pot holes are very numerous, as the country is very irregular, and they vary in size from a puddle to a pool one hundred feet in diameter: sometimes so shallow as to hold water for a brief period only in early spring; in a few cases so deep as to be practically permanent: sometimes without vegetation or insect life other than mosquito wrigglers: sometimes with aquatic life in considerable variety—mosquitoes being then, as a rule, absent. In some of these pools wrigglers occurred in considerable numbers, and here *C. abfitchii* was in greater abundance than we had ever known it before—much more plentiful than *C. canadensis*, which was but sparsely represented. Several swampy woodland areas were examined and no wrigglers of any kind were found; predatory aquatic life occurred in abundance and wrigglers simply could not live here. A part of this area is overgrown with skunk cabbages,

and we have never found wrigglers in such places. So, also, there is a considerable black mud, swampy area between Morris turnpike, Millburn avenue and Short Hills road, which looks nasty, but where absolutely no wrigglers were found and where none were found at any time later in the season.

In the southeastern portion of the township is a large, low area, mostly dry, at time of examination, but with a series of badly-arranged ditches, which had no proper outlet. In these ditches puddles had formed and many of these were swarming with larvæ of *C. sylvestris*. So at the sides of the road were a number of pools, and some of these contained larvæ of the same species. Practically no large danger areas were found and the bulk of the mosquito life in the township was developing in the pot holes.

As to the *Culex sylvestris* found breeding in the ditches and along the roadsides, this favors open waters and swampy areas, and rarely gets into real woodland pools. It does get under the trees, in some cases, but rarely occurs in pot holes. It has a succession of broods throughout the season, is not a vicious biter, flies for a considerable distance and gets freely on porches, though rarely into houses.

May 17th, the territory between South Orange and Millburn was covered by Mr. Brehme, who found the pools pretty well dried out; took no larvæ and less than twenty adult mosquitoes, all of them woods species, not definitely determined.

May 22d, twelve adults were received from Short Hills, and all were *abfitchii*.

May 27th, Mr. Grossbeck and Mr. Brehme drove over this area together after a day and night of heavy rain. This had refilled the dried-out depressions and had added to those that yet contained water, but in only one place were wrigglers found. This was in a pool that had turned foul before the rain and contained one specimen of *Anopheles* and a number of the predatory *Corethra* larvæ—producing the short-beaked mosquitoes that cannot bite. As for adults, there were plenty of them. On the streets, in all the roads, on the porches, in the hotels—all *C. cantator,* and hundreds of them. They simply covered the horse while driving along the Rahway river. This was a salt marsh migration from the Linden marsh, where brood 2 was on the wing, about May 21st, and proved to demonstration the necessity for the marsh work before the local work could be expected to count. Mr.

Grossbeck suggests in his report: "A dozen others [*cantator*] were taken on the weather-boards under a porch on Springfield avenue. It is worthy of note that this dwelling was close to the spot where *C. sylvestris* was found breeding on May 3d, and that no specimens of this species were seen at this time. In no instance was any species other than *C. cantator* seen in the roadways or on houses where we looked.

"On the other hand, when we got into the woods, *cantator* disappeared and *siphonalis* [*abfitchii*] was common, and bit ravenously. *C. siphonalis* is scarcely to be distinguished from *cantans* in the adult stage and not at all when they are even slightly flown; but since the larvæ of the former species were common here May 2d, it is safe to say that this is the species we now encountered." Two examples of *C. pretans* were also taken.

June 3d, a box of specimens said to have been captured on the South Mountain Reservation were sent in by Mr. Renwick with the statement that "mosquitoes were very hungry in the reservation." These were twenty *abfitchii* and four *cantator*. These are the two species found by Mr. Grossbeck a few day previously, and the sending indicates a woods rather than a road capture.

June 5th, Mr. Brehme again covered the territory from South mountain to Millburn, taking no adults on the way, but turning out a few larvæ between Short Hills road and the cemetery. These were found to be half-grown *C. sylvestris* and a few *C. trivittatus*. Later in the day, on the South Mountain Reservation, twenty-three adults were taken, twenty *cantator* and three *sollicitans*, the latter making its first appearance in the marsh migrations.

June 11th, on the South Mountain Reservation all the pools were dried out, but 118 adults were collected, of which 117 were *cantator* and one was *canadensis*. At Millburn and Short Hills breeding conditions were very similar, and as the wind was blowing briskly no adults were found flying.

June 14th, Messrs. Brehme and Grossbeck again covered the ground together and found absolutely no local breeding in progress. In the bright sunny roadways no mosquitos were found. In the swampy woodland area between Millburn avenue, Morris turnpike and Short Hills road mosquitoes were present in great numbers, and with few exceptions they were *cantator*, the salt-marsh species; the exceptions were either *cantans* or *abfitchii*, probably the latter.

In the pot-hole area, though many of the holes held water, no breeding was in progress, but adults were present in great numbers. *Cantans* or *abfitchii* were most abundant in the ratio of ten to one *cantator,* and all were vicious in the attack. A few *sylvestris* were also seen, but these were timid and more frequently alighted on the clothing than on exposed portions of the body. In all cases they were very slow in biting, in marked contrast to the *cantans.*

June 25th, Mr. Brehme again collected over this area finding no more breeding, and nine worn *C. cantator,* five fresh *C. sollicitans* from the third Elizabeth brood and one worn *C. cantans.*

On the same day, out of fifteen examples caught in Mr. Renwick's garden, fourteen were *cantans* or *abfitchii* and one was *cantator.*

June 26th, Mr. Brehme and Mr. Grossbeck made another collection and examination of the pot holes. For over a week there had been frequent rains and enough time had elapsed since the first to bring out any mosquito larvæ that may have been ready to develop. But though many pools were found with water, absolutely no larvæ were present. Adults were still numerous and fierce and all save 3 to 4 per cent. of *cantator* were *abfitchii* or *cantans.* The latter were much worn, however, and survivors of the early May brood. "It was interesting to see how this species keeps to the woods. Ten feet from the woods not a specimen was to be seen, but upon entering a few feet into it one would be at once surrounded by a humming swarm. They alight without hesitation and bite directly. About 100 specimens were taken in less than ten minutes."

What Mr. Grossbeck says above shows that it is quite possible for two persons to collect over the same area and make quite a different showing at the end of the day. The one keeping in the open would get *C. cantator* almost exclusively, the one keeping to the woods would have a strong predominance of *C. cantans.*

June 30th, another trip by Mr. Brehme showed neither larvæ nor adults at Springfield. At Millburn no larvæ were found, but there were plenty of *C. cantator* and a very few *C. cantans.* In the woods the number of mosquitoes was materially reduced and larvæ were yet absent. On the South mountain there was no breeding, and of twenty-seven adults, twenty-one were *C. cantator,* very much

worn; four were *C. sollicitans,* very fresh, and two were *C. cantans,* very old.

July 7th, the South Mountain Reservation was dry, no breeding was going on, the woods mosquitoes were not in evidence, and as it was quite windy, few of any sort were flying. Nine old specimens of *cantator* were taken, and there was no evidence that specimens from brood 4 of the salt marsh had yet reached this place. At Springfield everything was dry, and neither wrigglers nor adults were found.

July 14th, conditions at Springfield had not changed; at Millburn no larvæ were found, but a number of fresh *C. cantator* were taken, evidently recent arrivals from the marsh. At Short Hills the woodland pools were free from larvæ and mosquitoes were much less in evidence. At South mountain no larvæ were found, but there were fourteen fresh and four old *cantator* and three fresh *sollicitans.* The old migration from the salt marsh was almost gone, and fresh specimens had arrived to take its place.

July 18th, eight fresh examples of the house mosquito, *C. pipiens,* were sent in by Mr. Renwick, the first of the season from that source, and on the 21st Messrs. Brehme and Grossbeck made another joint investigation. There had been frequent rains for some days, and it was believed that conditions for local breeding should be at their best. The Springfield avenue low area at Millburn showed pools in the stream beds, some with and some without vegetation. In the more open pools *C. pipiens, C. sylvestris* and a few *jamaicensis* were breeding, while in those with vegetation *C. territans* and *Anopheles* were found. There were plenty of adult *C. sylvestris* near these pools, but none were found elsewhere on the meadow; they apparently remained very close to home. The area between Millburn avenue, Morris turnpike and Short Hills road was very wet, as usual, but absolutely no breeding was observed in any part of it. Not a wriggler of any kind was found, and only a few adults were found flying—all *sylvestris.* The pot holes in the woods were pretty generally filled with water, but absolutely no wrigglers were found in any of them. Adults were moderately abundant, four of them badly rubbed *cantans,* one *C. triseriatus* and the others all *C. sylvestris.* The latter gave very little trouble, and was usually content to alight on the clothing, making no attempt to bite. As the last sending from Mr. Renwick was all *C. pipiens,* and his sendings had been pretty generally

fresh-water forms, his house was located and found to be close to the woods and with trees, not a part of the original woodland extending well toward the porches. It was a situation which would readily tempt the sylvan species, and accounts for the predominance of *C. abfitchii* early in the season. No dangerous puddles were seen, though the grounds themselves were not examined, and attention was directed to the sewers. Several of the covering plates were lifted and beneath each was found a large settling bucket, full to the brim of dirty water. Most of them had no wrigglers, but some had, and directly in front of Mr. Renwick's house was a bucket with an egg-boat and numerous larvæ and pupæ. The local supply and recent occurrence of *C. pipiens* was thus readily explained, and attention was called to the matter.

During the day, while driving, the horse was frequently covered by mosquitoes, almost all *cantator,* and specimens of the same species were taken on Mr. Renwick's porch and in his garden. In the evening, on a hotel porch, both *C. cantator* and *C. pipiens* were taken—six of the former to one of the latter, but as there was considerable wind, mosquitoes were less than usually troublesome.

August 6th, breeding conditions from South mountain to Millburn were unchanged, and only a single lot of wrigglers was found. These were composed of six *C. serratus,* one *C. sylvestris* and one *Anopheles punctipennis.*

August 16th, Mr. Renwick sent in his last lot of adults for the season, composed of *C. cantator,* four; *C. sylvestris,* four, and *C. cantans,* two. This is the last appearance of *C. cantans* (more probably *abfitchii*) in the collections, and indicates a possible length of adult life of ten weeks—much longer than we had believed from previous experience, and that makes this single brooded species a much more serious pest than some other even more plentiful but shorter-lived species.

August 18th, Mr. Brehme, in tracing out the course of brood 6 from the Elizabeth marshes, covered the area from Springfield to Summit; and found ninety *sollicitans,* two *sylvestris* and one *pipiens.* On the South mountain the collections made were twenty-one *sylvestris,* five *cantator,* five *sollicitans,* one *canadensis,* one *triseriatus.* This was purely a tracer for adults and the search was continued on the 20th. From Millburn to South Orange road, seven *sollicitans,* three *cantator,* four *sylvestris,* one *triseriatus.* South Orange road to St. Cloud, two *sollicitans,* two *cantator,* four

sylvestris. St. Cloud to Montclair, seven *sylvestris,* one *cantator.* The dominance of the salt marsh fauna is well shown in this collection, but the migration was not then completed, as was found August 27th, when one hundred and fifty *sollicitans* and twenty *cantator* were taken at Millburn, as against two *sylvestris* and nine *pipiens.* On the South mountain, on the same day, were fourteen *sollicitans,* nine *cantator,* six *sylvestris* and one *Janthinosoma musica.* At Springfield, there were some pools and in them larvæ of *sylvestris, pipiens* and *Anopheles* were found.

September 4th, Springfield was still breeding the species above named and many larvæ were taken. *Sollicitans* and *cantator* were yet the dominant species, but the examples were beginning to look much worn, while *sylvestris,* which was the only other species taken, was very fresh and clean.

September 20th, practically all the breeding places in the entire area were dry, the salt marsh species had disappeared and only five *sylvestris* and one *pipiens* were taken during the day. The trip was made to verify the conclusion that marsh brood 7 was a stay-at-home, and that no migration had taken place.

September 24th and 25th, Messrs. Grossbeck and Brehme tramped the entire area under observation, and in the two days found only a single adult *C. sylvestris* and no larvæ at all. In the Springfield area of Millburn the stream bed, which had been broken up into pools earlier in the season, was now full, and no more breeding was going on. Nothing was found in any of the pot holes, and the swamp areas were all safe.

October 9th, matters were found in an equally good condition, so far as breeding is concerned, and in the day's search only five adults were met with, all *C. pipiens.*

October 16th, I went over the area myself with Messrs. Brehme and Grossbeck to verify the conclusions that they had reached, and to be able to speak of the character of the area from personal knowledge. The "pot holes" I found like those I had known in other places and none of them contained larvæ. From two of them that were dried out, or nearly so, a pail of surface soil was gathered, a shaving one-quarter inch, or a little more, being taken so as to include the decayed leaves and the mud surface just beneath them. This was carefully examined later, in the laboratory, and mosquito eggs were found imbedded in it. These eggs were like those of *sollicitans,* but distinctly larger, and therefore were

not those of *canadensis* which I have had, and which are smaller. They were probably either *cantans* or *abfitchii*. None of these eggs hatched under laboratory conditions.

These pot holes are real danger points, and more particularly the smaller, less permanent ones, and they need attention, though they produce only a single brood annually.

As to the rest of the woodland and swamp areas, they need little or no attention, and no signs of breeding were observed. Along some of the roadsides water-filled depressions were seen, and in some of them larvæ of *C. sylvestris, C. restuans* and *Anopheles punctipennis* were found in small numbers.

This series of observations carried on throughout the season demonstrates that for the entire area covered by it the salt marsh species are the dominant and annoying types, except in the woods in which the pot holes occur, and there *cantans, abfitchii* or *canadensis* may be expected to be the pestiferous forms. The occurrence of *abfitchii* this year is quite out of the course of our experience and may not be repeated for some years; but, on the other hand, the experience may be duplicated next year. Our stock of facts is as yet too small to make it safe for us to generalize or predict.

All of the inhabitants of this region are affected by the marsh mosquitoes; only those who live very close to or actually in the wooded area are apt to be troubled by the sylvan species. There are no dangerous swamp areas of any extent anywhere within the surveyed area. There are several places where pools form at times and from which *Culex sylvestris, pipiens, restuans* and *Anopheles* are bred in greater or less numbers, but most of these places can be easily and cheaply abolished. It is quite probable that there are places where *Culex pipiens* breeds that can only be found by a house-to-house inspection and which we could not find because we entered no enclosures.

The drainage of the Elizabeth and Linden marshes, which is to be undertaken in 1907, will give relief from the salt meadow species and will leave the sylvan forms as the principal source of trouble from May to mid July. Just how far the individuals fly within the woodland we do not know; we do know that they will not go outside of the woodland or from the shelter of trees. It is not probable that any stretch of open would be crossed to get from

one patch of woods to another, but even a wide road through the woods would be freely crossed at night, though no mosquitoes would be found on it during the day.

A few of these pot holes may be easily and cheaply drained, and that will be the best way of getting rid of such. A great many of them can be easily filled with soil from the surrounding hillocks. There will remain a considerable number that cannot be easily drained and which it would be rather expensive to fill in the ordinary way. These would have to be dealt with by oiling or by making them unsuitable for mosquito breeding. Oiling is usually an unsatisfactory makeshift and not to be recommended, and yet it deserves consideration in this connection because it would have to be done once only. None of the sylvan species except *C. canadensis* have more than one brood, and this matures in late April or early May—usually the latter. A couple of men with knapsack sprayers and a supply wagon could cover a very large area in one day and could oil-cover the pools in it so thoroughly that few larvæ could come to maturity. Done once, the task would be finished for the season, and each year would make it easier, since persistent thorough work results in practical extermination in all the easily accessible pools. The matter is worth careful consideration.

To render the pools unfit for breeding places would mean to cover them in such a way as to prevent the larva from getting free access to the air. These pot holes are natural sinks into which the water drains from the surrounding slopes, but while the hole may be inevitable, it need not remain freely open to mosquitoes. It could be loosely filled with stones and boulders, over which logs and branches could be piled in such a way as to form a rather solid covering to the pool so dense as to make it uninviting as a breeding place. Mosquitoes do not like too much shade, and even a filling with branches of trees cut into short lengths would be sufficient in many instances. This would cost more than oiling, but would be more permanent, though it would have to be looked over at intervals of two or three years.

As to the other breeding places for *sylvestris* and its companions, a few intelligently-placed ditches, a little filling and a few culverts or pipes across roads will be nearly all that is necessary.

New Durham.

Early in May, after some correspondence, I met with a committee from the board of trade of New Durham to look over the general mosquito situation. The town is on the Palisades, and the slope is abrupt to the Hackensack valley. The Erie and New York and New Jersey railroad tracks run between the foot of the Palisades and the Penhorn creek, leaving a considerable swamp area to which the railroad embankments serve as an outer dam. There is also a swampy area between the two lines where, at the time of my visit, water was standing, but no wrigglers were apparent.

Mr. Brehme was detailed to make a more careful study of the surroundings, and did so on May 15th. The cat-tail and reed-covered area of the valley had been under observation for two years previously, and was known to be safe, yet it was again examined to make certain that conditions remained the same. It was found also that while at the time of the examination no larvæ were present, a part at least of the swamp area basing the Palisades might become breeding ground for *C. pipiens* or *sylvestris*. This danger area was mapped out, a ditch system for its relief was suggested, and on the evening of the 23d a public lecture was delivered at the town hall under the auspices of the board of trade.

The matter was then left with the local authorities as one that did not come within the scope of the State Aid law, but it was also agreed that the territory would be kept under observation during the season.

June 28th, Mr. Brehme made a second investigation and found that the breeding places had been over, rather than under, estimated, and that some of the supposed dangerous ground was then so densely overgrown that no larvæ could possibly breed in it. And this safe condition persisted during the balance of the year. At this time some mosquitoes were noted early in the evening, and nine *cantator,* seven *sollicitans* and one *pipiens* were taken—sixteen salt marsh specimens and one local.

July 19th, conditions in the suspected areas were still good, but mosquitoes were very abundant. The wind had been from the southwest for several days and representatives of brood 5, from the Jersey City meadows, were on hand. Yet *C. pipiens* was well

represented, also, and the question was where did they come from. There are no large breeding areas, so there must be local conditions on enclosed property, which are only within the jurisdiction of the health officer.

August 22d, on another visit, breeding places within the town limits were sought out and quite a number were found—some in pools in depressed lots, but more in gutters, where larvæ and pupæ were plentiful. The excess of rain, which kept such places constantly full, was responsible for much of the mosquito trouble. The vast majority of the adults were of the salt marsh species, however, and representatives of brood 6, which was just out from the Jersey City meadow.

A report of all our findings was duly transmitted to the board of trade, at their request, and will form the basis of whatever positive action is taken in the case.

Lake Hopatcong.

This pretty lake is becoming increasingly popular each year, and not only are hotels and other resorts becoming more numerous, but camps have been and are being established in the woods round about. Complaints of mosquito troubles are occasionally received, but the general belief seems to be that the lake itself is responsible, and that therefore nothing can be done—that it is simply one of the drawbacks inseparable from any body of water. Nothing is further from the truth, and it had been intended to keep a rather close watch on the locality during the summer. This proved to be impossible, owing to press of other work.

Two days' collecting was done—May 5th and 6th—by Mr. Grossbeck, on the east side of the lake, through the swampy area and among such woodland pools as were found. Larvæ of *Anopheles* and *C. sylvestris* only were found on this trip, which was too late for the spring forms, and these larvæ were in a single pool close to an open field. Neither of these species are true woods mosquitoes, and frequent either open areas or get as near to them as they can. As to the adults, *C. aurifer* was very abundant and in good condition in one section of the woods. During a rest of twenty minutes twenty examples were taken and pinned, out of the hundred or more that were hovering about—and not only

hovering, either, for Mr. Grossbeck found them as vicious as Mr. Brakeley did at Lahaway in former years. Where this *aurifer* occurred it was the only species and probably bred close by, although no breeding place could then be identified as such. The records made by Mr. Brakeley prove that this is one of the single-brooded species, maturing in April, but that the adults may live until midsummer, ready to bite viciously to the end. Mr. Brakeley's observations further prove that the species does not occur each year in notable numbers, but that in some seasons neither larvæ nor adults can be found in places where the year before both were abundant, even where the conditions of moisture are approximately identical.

"In another section, an open swampy area, *C. trivittatus* flocked about me while walking, and they bit readily. Numbers were disturbed in and rose from the grass, alighting on the lower part of my clothing. This is the smallest mosquito that I have ever found in numbers in the field eager to bite, so it attracted attention at once. All the specimens were badly rubbed." This is the earliest record that we have for this species, and indications now point to successive broods throughout the summer. That it bites readily is now also established, but thus far no examples have been found in or about dwellings.

In yet other parts of the woods *C. cantans* were found commonly, and they bit ravenously. The specimens were very much worn, as if they had been on the wing for some time, and it is possible that there may have been an admixture of one of the other species that are closely allied in the adult stage. On the porch of the hotel a few *aurifer,* one *canadensis* and two *perturbans* were taken at dusk, showing that these may become nuisances.

July 7th, another visit was made, this time to the southern end, and with the especial object of determining whether one of the smaller lakes or ponds, on the edge of which a club-house was contemplated, was a mosquito breeder. It was found that it was not; that the pond had clean edges; was without shallows or vegetation rising above the surface, and was well stocked with fish. In the woods around about *C. cantans* was still found in considerable numbers, and there were also found the pot holes, some yet containing water, from which these specimens had been bred earlier in the year. No larvæ of any kind were found in the pot holes

that contained water, but in a shallow pool in an open field, larvæ of *Anopheles* and of *C. territans* were found.

The problem at Hopatcong is a purely local one, and neither the main lake nor the smaller lakes or ponds near it are to be accounted as sources of danger. The pot holes and other woodland pools which produce a brood of vicious biters in early spring need attention, and must be dealt with as local conditions indicate.

Mount Holly.

Mount Holly is a flourishing community with a population ranking high in prosperity and intelligence. It is the county seat of Burlington county, one of the most important in the State, and it is the centre for the surrounding agricultural section, which comprises some of our best farms and orchards. That Mount Holly should have an improvement association is not surprising, and that this association should consider the subject of getting rid of the mosquito pest is only natural. At the request of this association, Mr. Grossbeck visited Mount Holly June 8th, and what he found is best shown in the report, which is here given verbatim as made:

"*Mount Holly Improvement Association:*

"GENTLEMEN—Pursuant to your request that a mosquito investigation be made in Mount Holly and its breeding places located, I beg to submit herewith my report:

"The town was inspected on June 8th of the present year, in company with your president, Mr. Joseph R. Gillam. Your town, as you are probably aware, is without the limits of the migratory salt marsh mosquitoes, so it follows that all the nuisance is caused by local species, the principal one of which was found to be *Culex pipiens*, the house or the rain-barrel mosquito. This species was found in countless numbers throughout the town. There were also found a number of places which are typical for a luxuriant development of *Anopheles* or malaria carriers. Indeed, this species was found breeding in certain barrels, but in such places they occur only in comparatively small numbers.

"Following are enumerated the different breeding places found and remedies are suggested for their elimination, which where feasible are of a permanent character:

"At the northwest corner of Washington and King streets the ruins of the carpet mill enclose a large pool of water which is uninhabited by natural enemies of mosquitoes of any kind. This body of water, though free from mosquito larvæ at the time of investigation, is, nevertheless, subject to their invasion, and will undoubtedly harbor millions of individuals before the end of the season. This place can be easily drained into the Rancocas creek by an open ditch and the area thus made safe. Between the mill and Washington street the land is low and wet and in times of continual rains will become dangerous. Therefore a ditch should be made to connect with the one to drain the pool just mentioned which will render this place dry at all times.

"There are five wooden railroad bridges crossing the Rancocas creek and at each of these are several barrels sunk into the earth and filled with water. Most of these were swarming with mosquitoes in all stages from egg boats to pupæ, and freshly-emerged adults were to be seen resting on the surface of the water. In one of these barrels were found, also, a number of larvæ of the malaria-carrying species (*Anopheles*). Tightly screening these barrels so as to prevent the entrance of adults would be the best remedy, but this recommendation may be difficult to carry out since it partially destroys the purpose of the barrels. Petrolizing, *i. e.*, pouring crude petroleum on the water, is the next best thing that can be done, but this will have to be repeated at intervals of a week or ten days. This is a very effective method for killing the larvæ since it shuts off their only means of obtaining air, but on account of the liability of its being neglected or procrastinated it is not recommended except when no permanent method is possible.

"There is a small area south of the railroad station south of Washington street which, though quite safe, will breed *Anopheles* and *Culex territans* in small numbers. This place should be drained by a few ditches into the creek.

"In the meadow at the foot of Bispham street, between the railroad and the creek, and known as Parson's meadows, are several small ditches which widen out at places forming shallows with a luxuriant growth of water vegetation. These are ideal breeding places for *Anopheles* mosquitoes. All these ditches should be deepened and the edges kept clear from vegetable growth, thus giving the water a free circulation and incidentally giving ready access to the small fish which are numerous in the nearby creek.

"The partially wooded area south of the railroad called Spout's Spring woods is not a breeder of species which are classed as nuisances, but in many of the open spots *Anopheles* will develop, and it therefore needs some attention. It can be drained by open ditches into the creek. Should work in elimination of breeding areas be commenced by the improvement association, I would suggest that this be the last of the places to be dealt with.

"The area north of the railroad and west of St. Andrew's cemetery has precisely the same conditions as Parson's meadows, and the recommendations given for that territory applies to this as well.

"Directly to the rear of the Relief Fire Engine House was found a very large pool. This contained millions of *Culix pipiens* larvæ and pupæ, and in itself could supply the town of Mount Holly with a plague of adults. Considering the number of broods the pool would develop in one season, the number of individuals in all would run into an unpronounceable row of figures. A series of somewhat smaller pools followed this, and all are dangerous, though all did not contain larvæ when examined.

"The old raceway from the dam to the old grist mill was found to be a prolific source of mosquito breeding, both for *Culex pipiens* and *Anopheles*. Large pools have formed in the deeper depressions and I understand that these are only rarely connected by a continuous channel of water. The same conditions were found below the grist mill, where a single dip of an ordinary glass brought up a wriggling mass of mosquito larvæ. This place, I am informed, is to be permanently remedied by the building of a dam across the Rancocas creek, thus directing a steady stream of water through the raceway. Until this permanent work can be done, petrolizing the pools at intervals of ten days is recommended as a temporary expedient.

"Near the Grant street station there is a small, wet area, which was found to be breeding *pipiens*. This can be drained very easily into the sewer pipe.

"To the rear of dwellings on Water street, just west of King street, were found many puddles formed by the sewage from the houses. These were simply blackened by thousands of pupæ which crowded the surface. There are undoubtedly other such places in the town, as well as open ditches at the sides of the roadway in which surface sewage gathers, and all such give rise to perfect

clouds of mosquitoes many times in the course of one season. I am informed that there is a good sewerage system in Mount Holly, and if all dwellings were connected with this these surface sewage pools would be eradicated."

In order to bring the matter more prominently before the public, Mr. Dickerson delivered a lecture on the subject, June 11th, detailing the life history of the offending species and explaining just how the measures proposed were expected to produce the desired result.

The Improvement Association also republished the figures of the "Mosquito and the Puddle," first sent out by the Village Improvement Society of South Orange, and continued its campaign of education throughout the season. Unfortunately it proved impossible to secure the active co-operation of the authorities, and the character of the season was such that, with the supply found by Mr. Grossbeck to start on, every rain pool developed house mosquitoes when the rains came.

Mount Holly is out of the range of the salt marsh species. Its problem is a purely local one; is of such a character as to require only the simplest sort of local work, and such as to enable it to secure almost complete exemption by permanent improvements of not too expensive a character. It would be a reflection upon the intelligence of the municipal government should such conditions be allowed to remain much longer, especially where the board of health has ample power to compel abatement.

Other Local Work.

At the requests of either individuals or of the health or municipal authorities, local inspections were also made at Rahway, South Amboy, Barnegat City, Irvington, Plainfield, Montclair and Paterson, and in most cases reports were made to the parties concerned or who requested the investigations. Other communities sent in specimens for determination and a few localities were collected over for our own information.

The outcome of most of these inspections was to determine that the frequent rains and sultry weather of the late summer had furnished breeding places for *C. pipiens* in altogether unusual numbers; that every depression that could hold water was filled, and that wrigglers were present in almost every instance.

CULICIDE.

This material received its trial in New Orleans during the yellow fever epidemic and proved positively successful in destroying all mosquitoes in the rooms and buildings in which it was em-

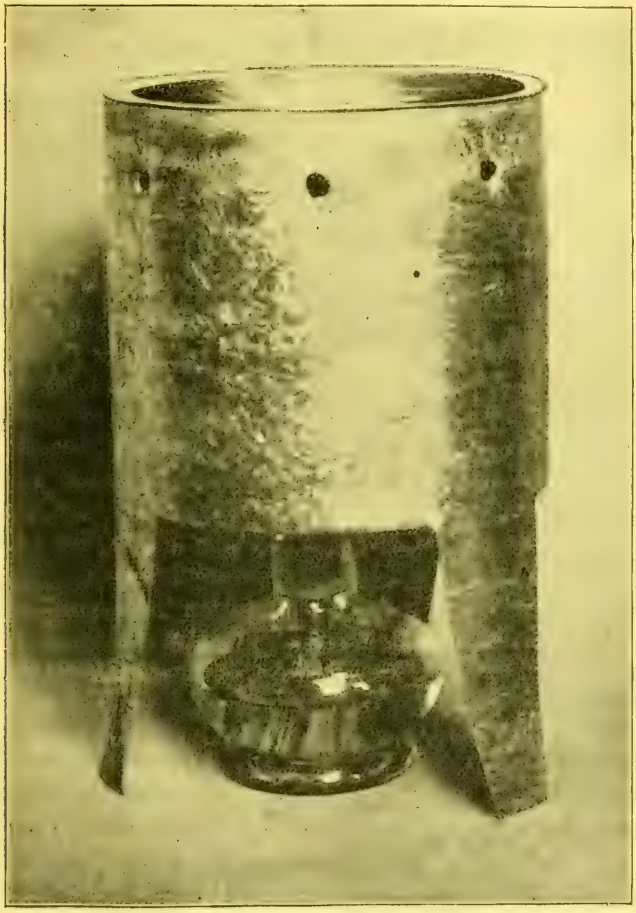

Fig. 7.

Fumigating outfit for Culicide. Made of a section of five-inch galvanized iron stove pipe, a tin dish and a glass alcohol lamp. From an original photo.

ployed. It is made of equal parts by weight of carbolic acid crystals and gum camphor. The directions are to melt the carbolic acid crystals over a gentle heat and pour over the gum camphor;

the acid will dissolve the camphor and leave a clear, somewhat volatile liquid with rather an agreeable odor. In actual practice I placed the bottle of crystals in a can of warm water and allowed it to liquify gradually, pouring the liquid over the camphor from time to time until no more acid remained. The resulting solution is permanent and may be kept in tight jars or bottles indefinitely.

The directions are to evaporate three ounces of this Culicide for every 1,000 cubic feet of space in the room or building to be treated and to keep such space tightly closed for a period of at least twenty minutes. Neither metals nor delicate fabrics are affected by the vapor, but besides mosquitoes it also kills flies and other insects. The liquid is inflammable, but not explosive, and as it requires heat to volatilize it, the apparatus should be placed in a pan or tub of water to avoid danger of fire.

Surgeon Berry, of the Marine Hospital Service, who gives an account of his experiments with the material in the Public Health Report for February 2d, 1906, Vol. XXI., No. 5, recommends as an outfit: "Galvanized iron stove pipe eight inches in length. Cut out sections from bottom so as to leave three legs, the cut-out sections giving entrance to air. This pipe is put over an alcohol lamp. In the upper part of the pipe make half a dozen air holes about one-fourth of an inch in diameter to provide a proper outlet for the draft. On top of the pipe place a pan in which the evaporation takes place. A granite ware wash basin answers every purpose and is better than anything else, because it evaporates the liquid completely."

In accordance with the above suggestion, I made the apparatus shown in Figure 7 out of five-inch stove pipe, and in a tin flat-bottomed basin that fitted into the top of the pipe evaporated two ounces of Culicide in twenty-five minutes, using one-half an ounce of alcohol in an ordinary glass alcohol lamp. A tin basin was used because it would heat up faster, and by measuring out at the rate of one ounce of alcohol for four ounces of Culicide complete evaporation may be obtained without danger of burning out the apparatus. It is possible to remain in the room until fumigation is well under way and the vapor becomes quite dense, and the room may be entered again when the work is completed after a door or window has been allowed to remain open a few minutes. Although

it has been found that twenty minutes' exposure is sufficient to kill mosquitoes, it will be better to allow rooms to remain closed tightly at least an hour after the material has completely evaporated. The quantity given, three ounces to 1,000 cubic feet of space, presupposes a moderately tight room to be fumigated. If doors or windows are leaky an excess should be used, and in large cellars, for instance, two or three fumigators are better than one to secure more rapid evaporation.

The entire outfit exclusive of the lamp, but including the charge of the tinman for cutting and punching the pipe, was forty cents. The actual outlay need not be over fifteen cents. Wood or denaturized alcohol will answer every purpose, so that the cost of the fumigating outfit is very small.

Killarvæ.

This is a preparation consisting of two powders which, when united in the presence of water, evolve or form ammonia. The water becomes more or less charged with this ammonia, in proportion to the amount of material used, and it is given off from the surface, as the very decided odor proves.

The preparation comes from the Nienstadt Laboratory, at Hoboken, New Jersey, and a sample was sent in for trial in May, supplemented later by a purchased lot, to be tried on a more extensive scale.

Quite a number of laboratory experiments and experiments on small areas were made, but condition proved adverse when a large area was undertaken at Barnegat, a brood having just come out of the pools and the water being clear at the time.

July 10th and 11th, applications were made to some lot pools containing larvæ of *C. pipiens* and *C. jamaicensis* at varying strengths, from that recommended on the packages to a concentrated mixture. The result of these experiments was, on the whole, unsatisfactory, and on July 18th the experiments were repeated, with Dr. A. E. Nienstadt, the inventor of the compound, in attendance. Four lot pools with large numbers of wrigglers were treated, and into each a large amount of the mixed powders was stirred. The pools varied in size and the ammonia odor was obvious in all cases. Check experiments were also carried on in

the laboratory, and the result was the destruction of nearly all the larvæ in all save one of the pools. Egg boats were also placed on the surface of treated water in the laboratory experiments, and these failed to hatch, while others from the same lot and placed on untreated water developed larvæ normally.

The net result of these experiments was that if used in sufficient quantity the "Killarvæ" does really kill mosquitoes in all stages, and the strong odor of ammonia rising from the surface will probably prevent oviposition for a short time.

Two days later, July 20th, Mr. Grossbeck re-examined the lot pools, found them partly dried up, but what water remained no longer had an alkaline reaction, and there was a new crop of young wrigglers. In other words, the pools were not protected for more than twenty-four hours.

This is not really surprising, for, since the killing power of the material depends largely upon the ammonia developed, it would cease to be effective as soon as all the ammonia was dissipated, and that goes very rapidly.

As compared with petroleum, "Killarvæ" is no more effective, and is, in fact, less certain, where pools are irregular and encumbered with vegetation. Nor does it protect for so long a time, for in a quiet pool the oil will serve for a week or two, while the "Killarvæ" disappears altogether in a day or two. Its only advantage over the oil is its cleanliness, and it may have a distinct and useful field in dealing with those woodland pools in which only a single spring brood develops. In this case any material that will with certainty kill off the larvæ before they have a chance to come to maturity will serve to free the treated forest district for an entire season from the offensive species that infest it. In such places as the Essex county parks its employment would be well repaid.

Report Upon an Experiment Having for its Object the Introduction of Gambusia Affinis and Heterandria Formosa to the Waters of New Jersey as Destroyers of Anopheles Larvæ.

BY WILLIAM P. SEAL.

It is probably best to premise that, as far as ocular evidence goes, the experiment in question has so far proven a failure, but it is not absolutely certain that this is the case, nor would it be proof of its impracticability. Having originally suggested the experiment, the writer, at the solicitation of Prof. John B. Smith, consented to carry it out.

In a paper presented at the last meeting of the American Mosquito Extermination Society, entitled "Fishes in Their Relation to the Mosquito Problem," the writer took the ground that the distribution of fishes for the purpose of mosquito extermination is as properly the function of fish commissions as the same work in the interests of sport, or even of food-supply, inasmuch as it relates to both the health and comfort of all our citizens, including the sportsmen.

It may be well, also, to note here that the writer suggested the same experiment to the United States Fish Commission as early as 1901, and was informed that "it was a subject not relevant to the functions of the commission, but pertinent to the Division of Entomology, Department of Agriculture." It is interesting to observe that the United States Bureau of Fisheries is now making the same experiment by the introduction of *Gambusia* and allied species from the costal waters of Texas to the canals and irrigating ditches of Hawaii.

The writer, in all suggestions on the subject, insisted on the month of March as the most favorable time for making the experi-

ment, for the reason that even if the fishes were inclined to escape from the waters in which they were placed, as an uncongenial environment, some of them would surely remain long enough to breed, and the young would most probably not be inclined to leave the place of their birth. It is a fact well known from experience with the food varieties that the larger species of fishes cannot be successfully introduced into waters which do not fully meet their requirements, and the rule holds good with all larger animal life. How far the rule will hold good with species so small and insignificant as *Gambusia* and *Heterandria* can only be determined by experiment. When once a species breeds in a locality its spread is generally only a question of time. It is, therefore, apparent that persistent and continued effort is necessary in making such experiments, and the greater the scale on which they are attempted the greater and more speedy will be the results.

As certain exigencies prevented the making of the experiment in the spring, it was deemed worth while to make it in the fall, so as to avoid further loss of time, and in the belief that there was a good chance for at least a small measure of success. The summer of 1905 was phenomenally dry, the drouth extending through the fall and greater part of the winter, so that many places naturally adapted to fishes like *Gambusia* and *Heterandria* were almost dry. If the fish had been living and breeding in these places all summer it would have made little difference, but in the cold season they were unfit as places for stocking.

The weather remained so warm throughout the fall that it was deemed undesirable to attempt to ship the fish before November, as the temperature in North Carolina, from which State they were brought, in that month was much like the month of June in New Jersey. In November, therefore, something over ten thousand were successfully shipped to Delair, New Jersey, from which point they were distributed as follows:

About 8,000 in spring and natural drainage rivulets flowing into the ice pond at Westville;

Six hundred in a land-locked pond near Delanco;

Six hundred in a mill pond between Merchantville and Evesboro;

Six hundred in land-locked waters near Delair;

Four hundred in ponds of the Aquarium Supply Company, at Delair.

The selection of the places for making the experiment was governed in the main by the desirability of convenience in maintaining some sort of espionage over them during the winter.

One of the small streams leading to the Westville pond comes from springs at North Woodbury. Another comes from the direction of the Delaware river, and it is now believed that in time of heavy rains small fishes could make their way to similar small rivulets flowing to the Delaware, but dense growths of briars prevent a complete examination. It must be, therefore, a matter of conjecture whether these fishes were devoured by the black bass, pike, yellow perch and sunfish inhabiting the Westville pond, or whether because of their enemies or dislike to their changed conditions they found their way during the spring rains to rivulets flowing to the Delaware. Some of them were seen during the winter and as late as March half a mile or more above the pond, and some still further up.

The Westville pond was looked upon as the most favorable in this section for the experiment, as affording average conditions, the possibility of escape by pushing up the rivulets leading to it not then being suspected; this, however, as before stated, being at present a matter of conjecture only.

When the fish were deposited the temperature of the water in the rivulets at Westville was about 45° F., or spring water temperature, and they seemed comfortable in it, but soon took refuge from the current in the grasses fringing the banks, disappearing completely from sight. In the other places the water was colder and the conditions more unfavorable and none of the fish were seen afterwards, and they probably succumbed to the cold or were devoured. In the ponds of the Aquarium Supply Company hundreds of young pike about one-half to three-quarters inch long were found in March, the breeders having found their way in through muskrat holes in the banks. In about sixty days they were four to five inches long, but not so numerous, their development representing the destruction of their kindred and all other species. It is the presence of the predaceous species everywhere that makes such experiments so difficult. In recommending that the supplying of fishes for the purpose of mosquito extermination be placed in the hands of the State Fish Commission, if it be deemed desirable to continue the experiment, the writer is actuated by the belief

that they will gladly undertake it if so authorized, and that with their extensive equipment and facilities the experiment can be made on a scale of such magnitude that success will be assured.

March, or not later than April, will be found to be the best season for shipping them by express. If accompanied by a fish commission messenger, May would not be too late. At all events the spring months are the proper ones for this work. The earlier the better. Then with the entire spring and summer for breeding, the multiplication will be manifold.

Gambusia affinis and *Heterandria formosa* are the smallest Cyprinodonts found on the Atlantic coast. They are viviparous, surface-feeding, larvæ-eating, minnows, know as "top-minnows." A study of the breeding habits of a pair of *Heterandria* during the past summer showed the extrusion of young at intervals averaging a week from June 13th to September 10th, some fourteen deliveries in all. These varied in the number of young extruded, but a fair average would be ten, although as high as eighteen were found on one occasion. Some were undoubtedly eaten when other food was scarce, though in the cases observed it might have been a parallel to what has been observed of other species where the young appeared to be devoured because they were deficient in vitality. Taking it, however, at the average of ten, there would be an increase from the one pair of one hundred and forty. Nor is this all. A pair born in June brought forth young in August and another pair did the same in September, thus producing a second generation within four months. It will thus be seen that they are wondrously prolific. Although they do not have the enormous fecundity of most fishes, the young are protected during the egg stage and are born able to take up the burdens of existence with a much greater chance of escape from their enemies as they are fully developed and very active at birth.

It can be safely assumed that the breeding habits of *Gambusia* are identical with those of *Heterandria*.

It is an established fact that these two species are largely feeders upon the larvæ of mosquitoes, and that because of their small size and habit of swimming and feeding at the surface, they can penetrate among and over aquatic plants as no other species can or do, and for this reason are especially adapted for the destruction of the larvæ of *Anopheles*. This phase of the question has, however, been quite fully explained and should be fully understood.

This report needs little comment; it is clear and to the point, and while the experiment is written down a failure it has taught us what must be avoided if success is to be secured, and it has taught us something concerning the limitations of the species. Concerning the desirability of securing the introduction of these little minnows into the State there seems little room for doubt, but the task is really beyond the scope of the mosquito work and should be placed where it belongs, *i. e.,* with the fish commission. There is no reason to believe that this commission will not be willing and fully competent to do all that can be done if the matter is referred to it with sufficient funds to cover the expenses involved.

MOSQUITOES OF THE SEASON.

Notes by John A. Grossbeck.

The summer of 1906 was rather a rainy one until the latter part of August, consequently favorable for prolific production of mosquitoes, and complaints were received from many points in the State. Upon investigation, the species in most cases proved to be *Culex pipiens,* the common house mosquito. This species is in some respects more of a nuisance than the salt marsh form, this latter being content to remain outdoors or to enter houses on the clothing, while the former's habit is to force its way into dwellings—through the meshes of the screen, if there is no more convenient method. As a rule, such complaints came from localities without the range of flight of the salt marsh species, but this does not mean that salt marsh mosquitoes have been less in numbers than usual, except in the drained areas, or that inland towns fared worse than shore municipalities, but the shore communities are never without mosquitoes in summer and the presence of additional specimens was not so marked.

The house mosquito also occurs along shore, sometimes in considerable numbers. The weather conditions of the season, as elsewhere, favored their development more than in ordinary years, but *C. sollicitans* and *C. cantator* are always the predominating species, and so *C. pipiens* is much less noticed than would be the case if salt marsh forms were absent, or nearly so. For instance, at Monmouth Beach, prior to 1904, one could collect hundreds of specimens, and most of them would be found to be *C. sollicitans*

or *cantator*. After the marsh surrounding this town was drained, the inhabitants enjoyed two years of solid comfort in having almost no mosquitoes. In the early part of the past summer, however, they were considerably annoyed and the work done on the marsh was questioned by some in consequence. Mr. Brehme, upon investigating the region, reported that he found *C. pipiens* breeding in great numbers in many places in the town—in neglected gutters, depressions in city lots, etc.—and, incidentally, going over the drained marsh area, he could not find any breeding going on there.

Two other closely related inland mosquitoes which were common and troublesome in 1906 are *Culex abfitchii* (*siphonalis*) and *Culex subcantans* (the *cantans* of previous reports). Prior to this year the former was regarded as rare and the latter had not been common since 1902. These two species are difficult to separate in the adult condition—in fact, in slightly flown specimens it is impossible to do so with any degree of certainty, the usually more robust appearance of *subcantans* being then the only means of discrimination. In the larval stages, however, the differences are marked and readily noticeable to the unaided eye, the most striking feature being the long and much more slender air-tube in *abfitchii*. Both these species are strictly sylvan in character, breeding only in woodland pools with *Culex canadensis*, and do not travel far from the immediate shelter of the trees. There is but one brood a year, the young larvæ hatching in early spring from over-wintering eggs and the adults issuing toward the last days of April, and continuing to emerge until the middle of May. Unlike most woodland species, these adults remain on the wing for several weeks, disappearing only in the last days of July. They are exceedingly hard "biters" and do not hesitate in making their presence known to anyone who enters their domain, but they voluntarily leave as soon as the open fields are reached. Dwellings situated near or among the trees where they occur are very apt to be troubled by these two species on the porches and in the gardens. They occurred in large numbers in the wooded districts of Millburn and Short Hills, Essex county, where they were taken in the first days of May as full-grown larvæ and later as adults. They occurred, also, in smaller numbers in the South Mountain Reservation and in the Great Piece meadows, and adults were taken plentifully in Paterson, on the Garret and Preakness

mountains, and in the woodland surrounding Lake Hopatcong. Our experience with these two forms has been such as would lead us to believe that next season they will in all probability occur in far less numbers, if they will not be altogether absent. Just what causes these broods to increase or diminish in numbers, as the case may be, is unknown; but it certainly does not depend upon the amount of individuals present the preceding summer, and if it be the conditions of the weather it must be from the time the eggs are laid until the beginning of the following winter, since from the time winter begins until larvæ appear in the pools seasons are much alike as regards the condition of places where eggs are laid.

The coast mosquitoes do not depend so much upon weather conditions as the inland species, since the pools in which they live are created by the tides as well as by rains. Nevertheless, in a summer such as 1906, the number and size of the broods is greatly increased. Thus the season was an ideal one for sending forth a continuous stream of adults until the droughty condition of the late summer put a check upon the rapid succession of broods. In the northern section of the coast line, and probably also in the southern half, *Culex cantator* was the dominant form in early spring. Toward midsummer *C. sollicitans* began to appear in a rather large percentage, though somewhat unevenly distributed as to numbers. At Elizabeth and Linden they were about evenly divided; at South Amboy and Staten Island almost the whole of the broods were composed of *sollicitans,* while in Jersey City *cantator* held the largest numbers. Toward the end of the summer, in the section from Barnegat bay southward, the broods were entirely made up of *sollicitans,* while north of this point *cantator* was present in only a small percentage.

Other less common mosquitoes.—Of the species of *Anopheles, punctipennis* remains by far the most common, appearing almost always in collections of *Culex pipiens,* whether from gutters, lot pools or rain barrels. Female adults were found flying as early as April 21st at Paterson, and larvæ began to appear all over the State in late May. They were most abundant in August, after which, the pools drying out soon after, they could only be found in springs, barrels and pails in which they were taken as late as October 18th.

Anopheles maculipennis has been rare for the past two or three years; in 1905 it was not taken at all in the larval condition, and in 1906 only a single adult was bred (June 1st) from a collected pupa from a "kettle-hole" at Millburn.

Anopheles barberi, discovered in New Jersey last year for the first time, was turned up by Mr. Brakeley at Bordentown, where he took adults in a bedroom at night: August 14th, one male; August 15th, one male and one female, and August 16th, two females. Another male was bred September 11th, from a lot of pupæ taken from a tree-hollow at Chester.

Anopheles crucians were taken in miscellaneous salt marsh collections at Barnegat City as small and medium-sized larvæ August 16th and September 6th, and at South Amboy as large larvæ and pupæ September 10th.

Psorophora ciliata was apparently rare throughout the season. Few larvæ were collected and adults were taken at Belleville, Paterson and in the Great Piece meadows.

Janthinosoma musica adults occurred plentifully in the Great Piece meadows August 27th. About twenty-five females were caged and fed on ripe banana and on human blood in hopes of getting eggs, but all died within ten days without ovipositing. Several adults were also taken at Lakehurst, August 16th.

Culex jamaicensis larvæ were found at Newark on July 25th; in pools along the speedway at Millburn, July 26th, in small numbers associated with *Culex pipiens* and *Anopheles;* and at New Brunswick in lot pools in great numbers on July 20th. This is undoubtedly the most rapidly developing mosquito in New Jersey. This was demonstrated at New Brunswick where larvæ as large as those of *C. pipiens* at maturity appeared July 20th, in pools which were absolutely free of mosquito life two days previous. On the 21st the larvæ were full grown, and among them were several recently-formed pupæ. It is worthy of note, perhaps, that, of this series of pools, only one contained *C. jamaicensis* and in that no *C. pipiens* were present, while in the adjacent pools *pipiens* were crowded in myriads and not a *jamaicensis* larva could be seen. Of the specimens collected for rearing a single male emerged on July 22d, making at most a four-day period from the hatching of the egg to the issuance of the adult. On the 23d, ninety males and twenty-five females emerged and all the larvæ had pupated, showing that the

eggs hatch and the larvæ develop very evenly. Many adults of both sexes were confined in breeding cages, one lot being fed only on ripe banana, the other exclusively on human blood. The latter took blood readily and gorged themselves so as to be utterly unable to take wing from a flat horizontal surface, though from a vertical surface they could fly short distances either higher or lower than the starting point, the tendency being to go downward. On a flat surface they could only hop about in a very comical manner. Of the examples fed on banana none lived above seven days, and of the blood feeders only two were alive August 6th, where one laid eighteen eggs upon the dampened lint, which was supposed to take the place of mud. They were laid singly, simliar to the manner in which *Culex sollicitans* lays her eggs; they were also of the same shape as those of that species but slightly larger. They were evidently not fecundated and failed to hatch whether covered immediately with water or left to dry out for several days before being water covered.

Culex discolor, though sent in from Delair by Mr. Seal every year since he first discovered it, is not as yet known to occur in any other part of New Jersey. A lot of full-grown larvæ were collected August 10th; on the 11th seven examples pupated which produced adults—all males—on the 13th. The remaining larvæ failed to pupate and grew more and more sluggish until their death —the last living until the 31st.

Culex perturbans as a larva remains unknown in nature though the young larvæ have been hatched during the past summer from eggs laid by a captive female. Though we have not succeeded in bringing the larvæ to maturity and thus establishing the character of their food, we nevertheless believe that we have taken a long step toward the final discovery of these early stages in a state of nature. The first record for *perturbans* in 1906 came from Mr. Brakeley, who found females sparingly at Lahaway in the last week of May. On June 8th he caught a male, the second example of that sex taken by him. From that date on the species became more common, but no more males were among the captures. Lakehurst, with its numerous creeks which flow through and spread over large and low-lying cedar and other woodland areas, represents conditions in which no known mosquito larvæ breed, and was carefully investigated for the larva that never occurred with other col-

lections of mosquitos. The locality was carefully examined in May before the first adults appeared and several times later in the summer, but nothing in the way of a mosquito larva was taken. On August 27th female adults in a very fresh condition were taken in the Great Piece meadows. They were most abundant around a shallow body of water in the midst of a piece of dense woodland, and they diminished in numbers the farther away one went from the pool, thus it seems probable that they bred in that body of water, even though at the time neither larvæ nor pupal skins could be found upon close examination. About thirty adults were taken alive and confined in breeding cages. They took blood readily, but one after another died off, until on September 8th there was but a single example left. Many of the dead ones had fully developed ovaries. On September 10th an egg-boat was found floating upon the water, laid by the last surviving female. The eggs hatched on the night of September 12th, and the young larvæ were transferred to strained water in which *Culex pipiens* had been breeding and into which pieces of stone, sod and decayed wood were placed in the hope that the larvæ would find in such a mixture some condition under which they might exist. Watched for several hours the larvæ rarely came to the surface, and only occasionally one or two were seen resting at the surface film. None lived more than six days, having apparently eaten nothing. The question still remains, therefore, as to just what the food of this larva is and under what conditions it lives. It has been suggested that they might be parasites, and this seems probable.

The egg-boat (Figure 8, 1) is quite similar to that of *Culex pipiens,* but is slightly larger, measuring 4.5 mm. at its greatest length and 2 mm. at its greatest width. It consisted of approximately 125 eggs, the individual egg being uniformly slaty-black in color, .75 mm. in height, broadest near the base and tapering regularly to a rounded apex. On account of the single eggs being longitudinally fastened together side by side and tapering apically, the top of the boat is very much smaller than bottom; indeed, some of the outside eggs are in an almost horizontal position.

The young larva (Figure 8, 2) is almost white in color and measures 1.5 mm., or .06 of an inch, in length from the head to the end of the ninth abdominal segment. The head is of the same color as the body, somewhat broader than long, well rounded in front, and

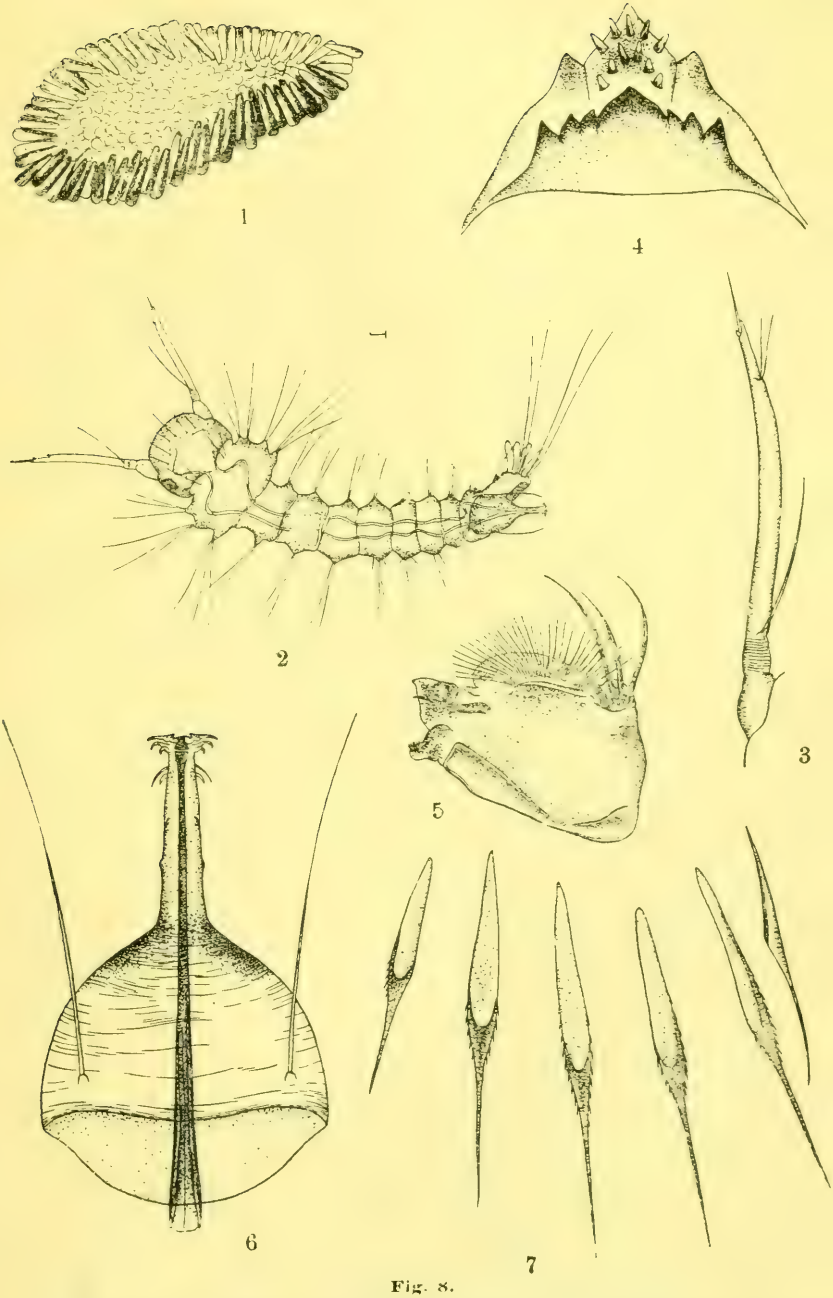

Fig. 8.

Culex perturbans. 1, egg-boat from above; 2, young larva; 3, its antenna; 4, mentum with hypopharynx; 5, mandible; 6, anal siphon; 7, patch of scales on eighth abdominal segment. Original.

with distinct offsets immediately before the eyes, upon which rest the antennæ. Six single hairs on the anterior half of the head arise from minute pits; two of these are situated further in front than the others and occupy the central portion. The eyes are black and rounded. The antennæ (Figure 8, 3) are exceedingly long and slender, swollen at the base, followed by a wrinkled portion, immediately above which arises a single long seta from a distinct tubercle; a short distance from the apex is a slight offset which sends forth two moderately long hairs, and the apex of the shaft is terminated by a small peg and long, sharp spine. The mentum (Figure 8, 4) is broadly pentagonal in form, with one large central tooth and three smaller ones on each side, becoming successively larger toward the base; the attached hypopharynx is three-lobed; the central lobe set with short, stout pegs. The mandible is very singular, departing in some respects from that of all known species, and is best described by a reference to Figure 8, 5. It is a chunky affair, possessing the usual fan-like structure and three long and a short, stout spine on the dorsal aspect. The peculiar structure lies in the fleshy portion, which extends beyond the apex of the teeth, thus indicating some special mode of feeding. The thorax is broader than long, with deeply-cleft sides, forming large teeth-like projections, from the apices of which arise two to four long hairs; two pairs of shorter hairs are also on the anterior margin, which extend forward over the head. The abdominal segments, 1 to 7, are subquadrate in form, the anterior ones produced into sharp points at the sides, from the tips of each of which arise two long hairs; the posterior segments are more transverse, with one or two shorter hairs at the sides and with several additional short hairs. Upon the dorsum of the eighth segment is situated the anal siphon or air-tube (Figure 8, 6); this is broad at the basal half, then suddenly constricted, and continues narrowly to apex, there terminated by several recurved hooks. There is no double row of spines or pecten, but on the ventral side are two very long setæ from tubercles situated widely separate from each other. The eighth segment also bears the lateral row of scales (Figure 8, 7), five to eight in number, with long spine-like apices, arranged in a single regular row. The ninth segment is longer than broad, with a chitinized saddle on the dorsum extending one-fourth the width of the segment down the sides. Four very long double hairs constitute the usual double dorsal tufts, and a ventral brush is absent.

The anal gills are about the length of the anal segment and finger-like in shape.

Culex taeniorhynchus appeared in collections made at Elizabeth June 3d and at Staten Island June 4th. A beautiful female specimen was also captured in the act of biting at Lakehurst on August 17th.

Culex sylvicola proved rare, even in its native home at Livingston Park, during the past season. About fifteen full-grown larvæ were taken on April 25th and several pupæ on May 11th, all of which produced adults on or before the 15th of the latter month. A single adult, much battered and parasitized, was captured at Mount Holly June 8th.

Culex fitchii (Felt & Young) was found for the first time in New Jersey during the past year. Only two larvæ were secured and neither brought to maturity. One specimen occurred among a lot of *C. canadensis* sent in from Lahaway by Mr. Brakeley, and collected April 22d; the other found with *C. cantans* and *canadensis,* collected April 21st in the Great Piece meadows. Being thus taken in places so widely remote from each other, it is quite probable that the species occurs sparingly throughout the State. This brings the list of species actually found in New Jersey up to forty-two. The adult insect is said to be indistinguishable from that of *Culex abfitchii,* but the larva is separable at once by the position of the individual spines of the pecten on the air-tube; in *abfitchii* these are placed at equal distances apart from each other, or at most those nearer the apex are slightly wider apart than those nearest the base, while in *fitchii* the two apical spines are widely separated from the rest and from each other. This character is very constant, and is always to be relied upon. In other respects the two larvæ are alike.

Culex sylvestris appears to occur in New Jersey in two distinct forms, which may represent distinct species, though no good characters can be found that will positively separate the two forms at all times. One of these invariably hatches from early spring collections occurring with *C. canadensis, cantans* and other species in woodland pools. It is much the smaller of the two forms, is darker in general appearance, and occurs in comparatively very small numbers—two to ten specimens hatching from one lot as against hundreds of specimens of the other species. It is found from the middle of April until the same time in May. The second form is

much larger and has never been taken earlier than the first days of May, and more usually much later. It does not occur in woodland pools, except rarely in such as may be close to the open fields, but is usually found in open swamp areas, lot-pools with clayey bottoms, etc., where the larvæ are found sometimes in immense numbers, crowded together and associated with no other species. This latter form is common until the end of the season. It seems probable that we have here a dimorphic species to deal with, the scant early brood being parent to the succeeding generations. Certain it is that the large form has been found in May in pools that were not in existence the year previous, indicating conclusively that the eggs had been laid the same year.

Culex signifer, it has been intimated, hibernates in the larval condition. This we were at first inclined to doubt, since all of our previous collections of larvæ of this species had been made in September and all came to maturity before the end of that month. To test the point more thoroughly, however, Mr. H. O. Marsh, of Chester, collected all the larval contents of a tree-hole April 22d, in which *signifer* larvæ were found the preceding year. Larvæ of *Culex triseriatus,* one-third grown, were found in some numbers, but no *signifer* larvæ were among them. In September Mr. Dickerson found in the same tree-hole small and half-grown larvæ of *signifer,* and up to the time of writing (November 10th) many of these are still in the laboratory and none have reached the pupal stage. In confinement in glass jars, however, even though kept in water taken from the tree-hole, larvæ do not obtain the proper nourishment necessary to their development, and unless they are almost full grown, will merely continue to exist, scarcely growing larger, and may linger on for months, as has been demonstrated with various other species. In view of this fact Mr. Marsh was again requested to examine the "*signifer* hole," and on November 17th he secured a full brood of the larvæ in all stages, from small to almost full grown. With them were two large larvæ of *Culex triseriatus.* Mr. Marsh said that there was about nine inches of water in the hole, and that the surface was covered by three-fourths of an inch thickness of ice; nevertheless, he said the larvæ were moving about actively. It appears, therefore, that this species does hibernate as a larva, and that the adults emerge early in the spring of the following year. It seems not to breed continuously through-

out the summer, appearing only in the fall after the maturation of the hibernating brood.

Culex canadensis, whose larvæ in early spring usually crowd the woodland pools, was conspicuous by its almost entire absence during the past year. It was present in some numbers in a few places, but as compared with former years this was entirely insignificant. In the hilly districts of Millburn, where there are a great many large woodland pools or "kettle-holes" most all of which form ideal breeding situations for this species, only a comparatively few larvæ occurred, and the resulting adults from this brood quickly disappeared. Each year that we study this form produces additional evidence which points more and more to the fact that this species cannot be counted among the truly pestiferous ones. It seems to disappear entirely a few weeks after emerging from the pupa, and this, coupled with the fact that it is rarely if ever found out of the immediate woodland where it breeds, renders it one which needs but little consideration from an economic standpoint. In the pools where they occur, however, certain other forms occasionally develop which are a menace to close-by dwellings, and pools treated for these will incidentally be freed from such *canadensis* as may be present.

Culex triseriatus, which normally breeds in the water in tree-holes and has on only two occasions been reported as occurring elsewhere, once in an iron kettle and once in a few pools formed by a drying brook, was found breeding continuously in pails in my back yard from mid-July until the end of August. The larvæ developed quickly, three distinct broods coming to maturity in that space of time. Most of the larvæ were taken from the pails as they neared maturity, but a few developed to adults outdoors, and one of these at one time was caught in the house toward evening. Two large larval examples were taken with a full brood of *Culex signifer* at Chester on November 17th.

Culex serratus was taken but once during the season, and then only half a dozen larvæ occurred among a lot of *C. sylvestris* secured by Mr. Brehme, August 6th, on the Orange mountains, a new locality for its occurrence.

Culex punctor, taken in New Jersey in 1905 for the first time, and then only as an adult, was found in 1906 as a larva on the Orange mountains and in the Livingston Park woodland area near

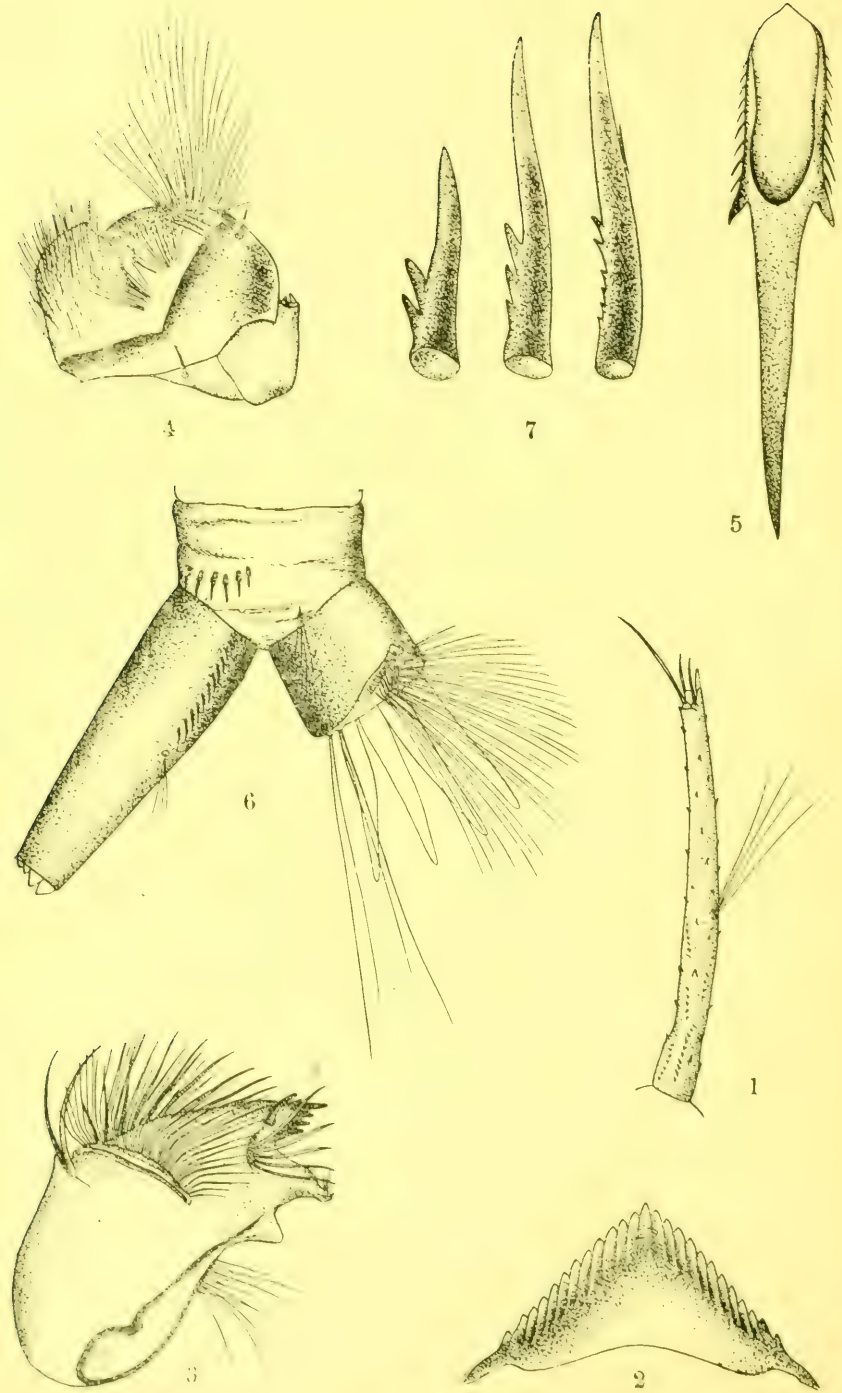

Fig. 9.

Anopheles punctipennis: details of larval structure. 1, antenna; 2, mentum; 3, mandible; 4, palpus; 5, a scale from the patch on segment 8; 6, anal siphon; 7, three spines from the pecten. Original.

New Brunswick. It appears to be among the earliest of our spring species. In 1905 adults hatched May 1st from pupæ collected April 28th, but no larvæ could be found among those still remaining unchanged, all having already transformed to the following stage. In 1906 the first larva was taken April 20th, associated with *C. canadensis* in a woodland pool on the Orange mountains. This changed to a pupa on the 23d and produced a male adult on April 27th. Two other larvæ were taken from the same locality on the 24th of April. On the 25th quite a number were secured from Livingston Park also in company with *canadensis,* and from this lot eleven males and three females emerged in the six days following. The larva has hitherto not been well described by this office, the description appearing in the preceding report being obtained from published data. It may be characterized as follows:

When full grown it is about 7 mm. or .28 of an inch in length, exclusive of the anal siphon. It is more robust than *canadensis,* though scarcely larger, and can usually be distinguished from that species by this fact alone. In color it is dirty yellowish-gray. The head is considerably broader than long, slightly excavated below the antennal offset and well rounded in front; four single hairs are on the central portion of the vertex, the posterior two situated immediately in front of the median line, the anterior two slightly in advance of these, and both lateral pairs placed rather wide apart. A single tuft of three hairs is at the base of each antenna. The antenna (Figure 9, 1) is uniformly grayish-brown in color, of moderate size, slightly and regularly curved inward, somewhat excavated a short distance from the base, giving the extreme base a swollen appearance, and terminated by one very long spine, three shorter ones and a short, stubby peg. The tuft, composed of four to six hairs, is situated on the shaft a little below the middle, and the surface of the antenna is set with short, stout spines and several rows of minute ones on the basal half. The mentum (Figure 9, 2) is broadly triangular with twelve or thirteen small regular teeth on each side of the apex. The mandible and palpus (Figure 9, 3 and 4), respectively, are of the usual *Culex* type and are best described by referring to the figures. The thorax is rather large and robust, with slight lateral angles which give rise to tufts of long hair; two smaller tufts are on the anterior margin. The abdominal segments from one to seven are subquadrate as usual,

with lateral hair tufts. The eighth segment bears the lateral scales; these are composed or six or seven single scales arranged in a regular curved row. The individual scale (Figure 9, 5) has a very long and strong apical spine and a number of small, hair-like ones fringe the sides, the one near the apical spine being much the largest. The anal siphon (Figure 9, 6) is a little over three times as long as broad and tapers evenly toward the apex. The double pecten is composed of twelve to fifteen spines, the single spine with two to five teeth on the basal portion, usually the fewer the number the larger their size as shown in Figure 9, 7. The anal segment is a little broader than long and entirely encircled by the chitinous ring. The double dorsal tuft and dorsal brush are normal and the anal gills are longer than the ninth segment and somewhat pointed.

Culex trivittatus was obtained in some numbers by Mr. Brehme in the Orange mountains June 5th, in a pool with a large brood of *Culex sylvestris*. Though almost full grown they proved hard to rear and only six adults, three of each sex, were secured. A few other larvæ were taken at Millburn, also with *sylvestris*, on June 4th.

Culex pretans occurred again as larvæ in great numbers in early spring in the Great Piece meadows, replacing *C. canadensis* in that place. Though absolutely no additional larvæ were taken subsequent to April 30th, adults were found on the wing as late as September 13th. Specimens taken at that time were caged and fed on banana and human blood, but all died in a few days without ovipositing. Examination of the specimens showed no eggs within the body and it is more than likely that the eggs had already been laid.

Culex aurifer, usually taken by Mr. Brakeley, proved rather rare. Only two larvæ were sent in by him, April 22d, and another was collected in the Great Piece meadows on April 21st. Adults were found in annoying numbers July 5th, in a patch of woodland on the east side of Lake Hopatcong.

Culex restuans was more abundant than in 1904 and 1905. It occurred quite generally in my breeding pails, appearing a little after the beginning of July, and was obtained from roadside puddles as late as the 16th of October. To it, in conjunction with

Culex pipiens, may be charged some of the sleepless nights that were experienced last season.

Culex salinarius also occurred quite generally over the salt marsh—never, however, appearing in very large numbers. They appeared about midsummer and were found as late as the early part of November. On August 13th, a single female was caught on the South Amboy meadow. It was caged and given a meal of blood, which it readily took, and on the 18th laid a loosely-constructed egg-boat, aggregating, approximately, seventy-five eggs. The young larvæ hatched on the 20th, ten making their advent at 3 o'clock P. M. and five others at 5 P. M., showing that the larvæ do not hatch simultaneously. They grew rapidly, considering their confinement, and on August 30th the first pupa was formed. This hatched September 1st and by September 7th the last of the entire lot had emerged.

This species occurs as late into the season as any other New Jersey form. Mr. Brehme reported an interesting observation, in November, 1905, which came too late for incorporation into the report for that year. He found full-grown larvæ in a pool on the Elizabeth marshes, which was covered with ice to the thickness of almost one-fourth of an inch that had formed during the preceding night. After the ice had been broken he found the larvæ lying at the bottom of the pool, and when scooped up with a net and transferred to a bottle showed scarcely any signs of life. In about five minutes (the bottle being exposed to the sun's rays) they began to wriggle slowly to the surface. When it was reached they ceased to wriggle and immediately sank to the bottom again. They then remained at the bottom for fully five minutes, and probably longer, before another attempt was made to obtain a fresh supply of air. It was not very long, however, before they were as active as ever, and in the laboratory almost all of them came to maturity.

Culex territans was found in my pails kept for breeding purposes on August 4th. This species confines itself, usually, to clear, fresh-water pools, and it is rare to find them in a water pail.

Uranotaenia sapphirina, a rather rare species in New Jersey, was taken in various stages of development in a woodland water area of the Great Piece meadows. The larvæ were very hard to rear, and, though a few reached the pupal stage, none became adult.

Of the species of Corethridæ, *Corethra cinctipes* was of rather

common occurrence in early spring collections from woodland pools. *Sayomyia albipes* was unusually rare, being taken only once at Millburn, on May 28th, while *Corethrella brakeleyi* was sent in by Mr. Brakeley in some numbers from Lahaway on April 20th. Full-grown larvæ of *S. albipes* were taken in the fall of 1905 and lived in the laboratory until January, 1906. They would probably have lived all winter were it not that no vegetation was growing in the jar in which they were confined, and the oxygen thus becoming exhausted resulted in their death. The larvæ of *C. brakeleyi*, on account of the grasping form of the antennæ and the sharp-toothed structure of the mandibles, were believed to be predaceous in habit, and during the present year one larva was seen with another half-devoured individual of the same species in its jaws. The larva of an allied species described during the past year was observed feeding upon a minute crustaceans.